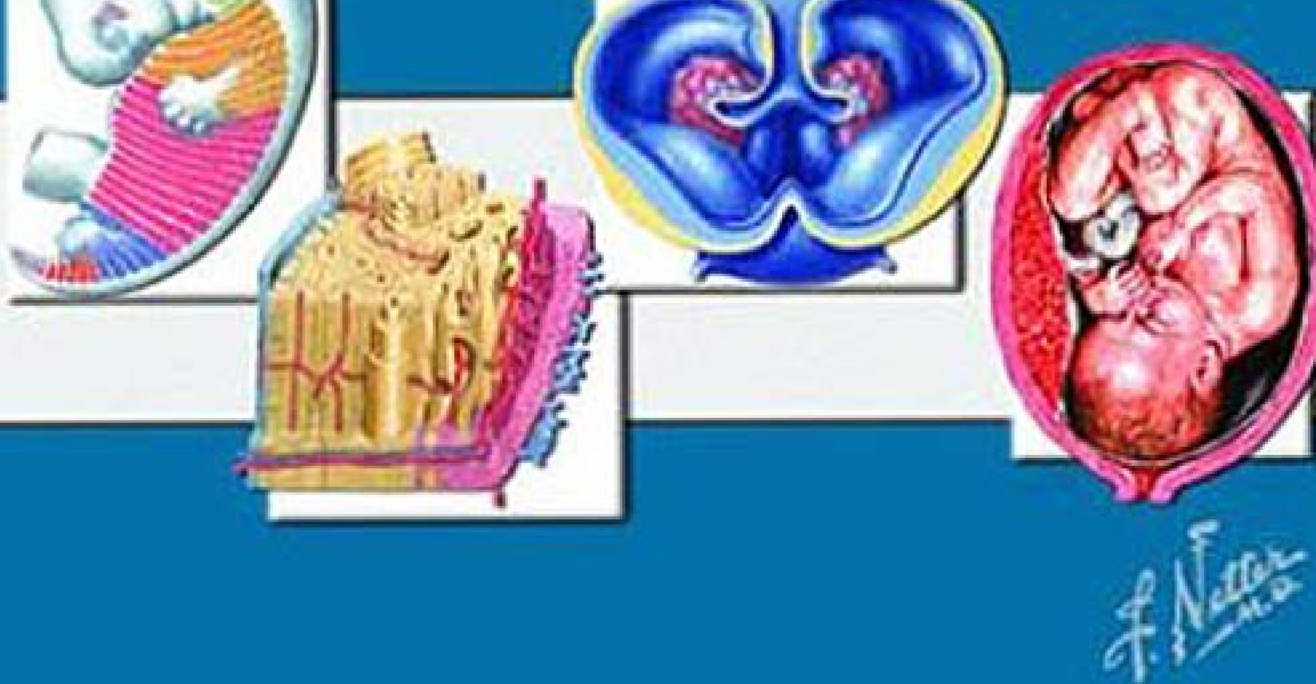
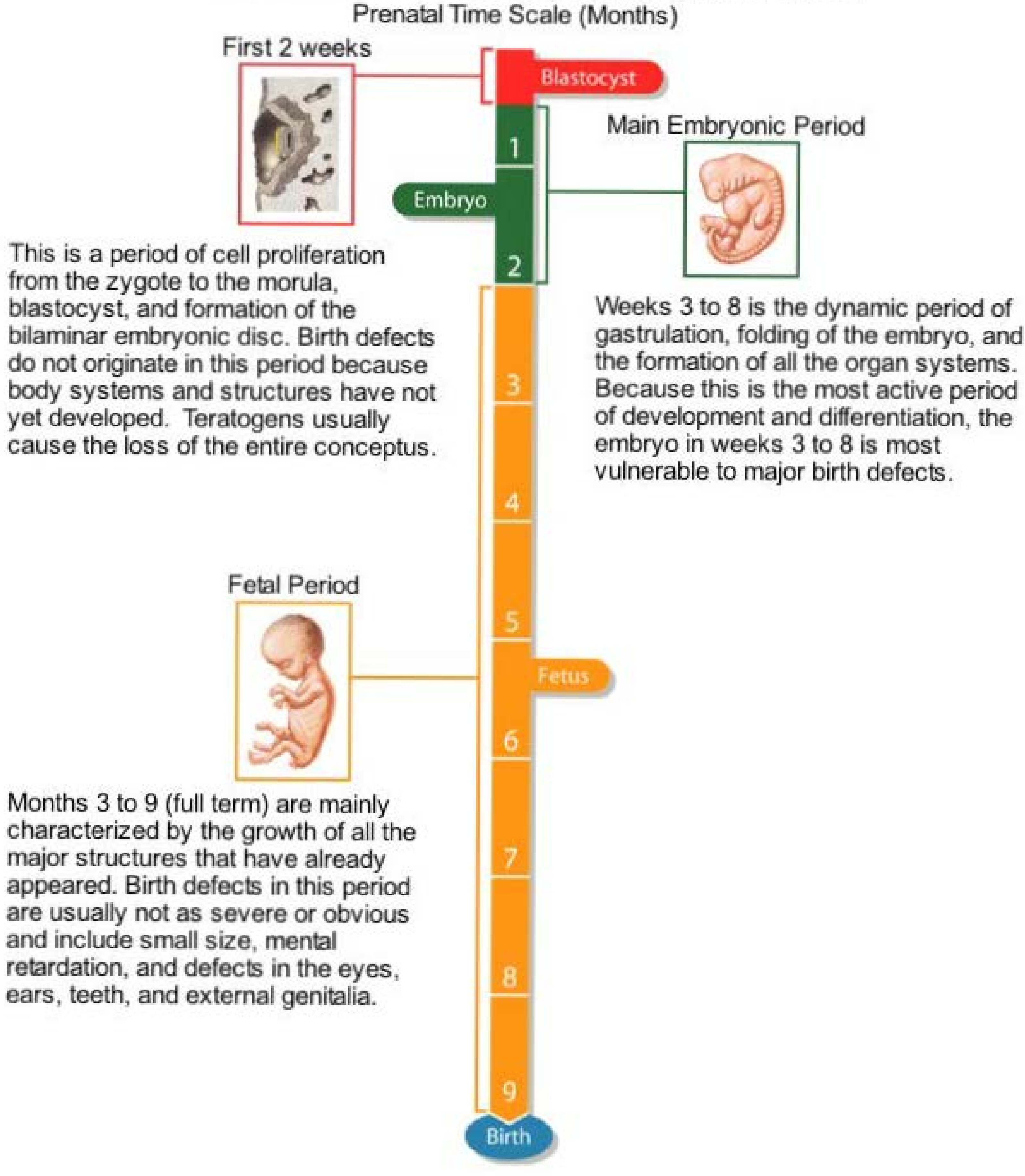
Netter's Atlas of Human Embryology

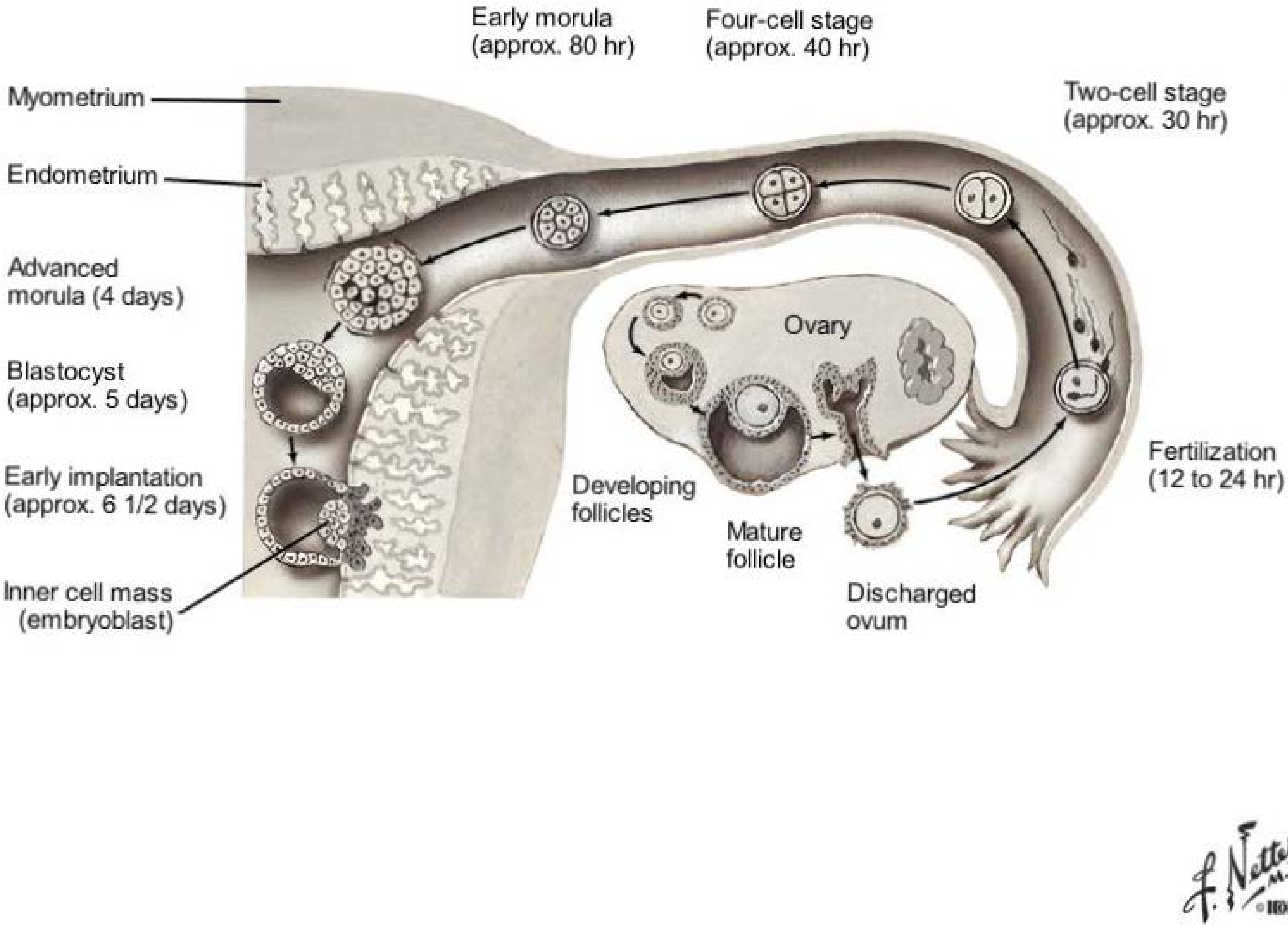
Larry Cochard



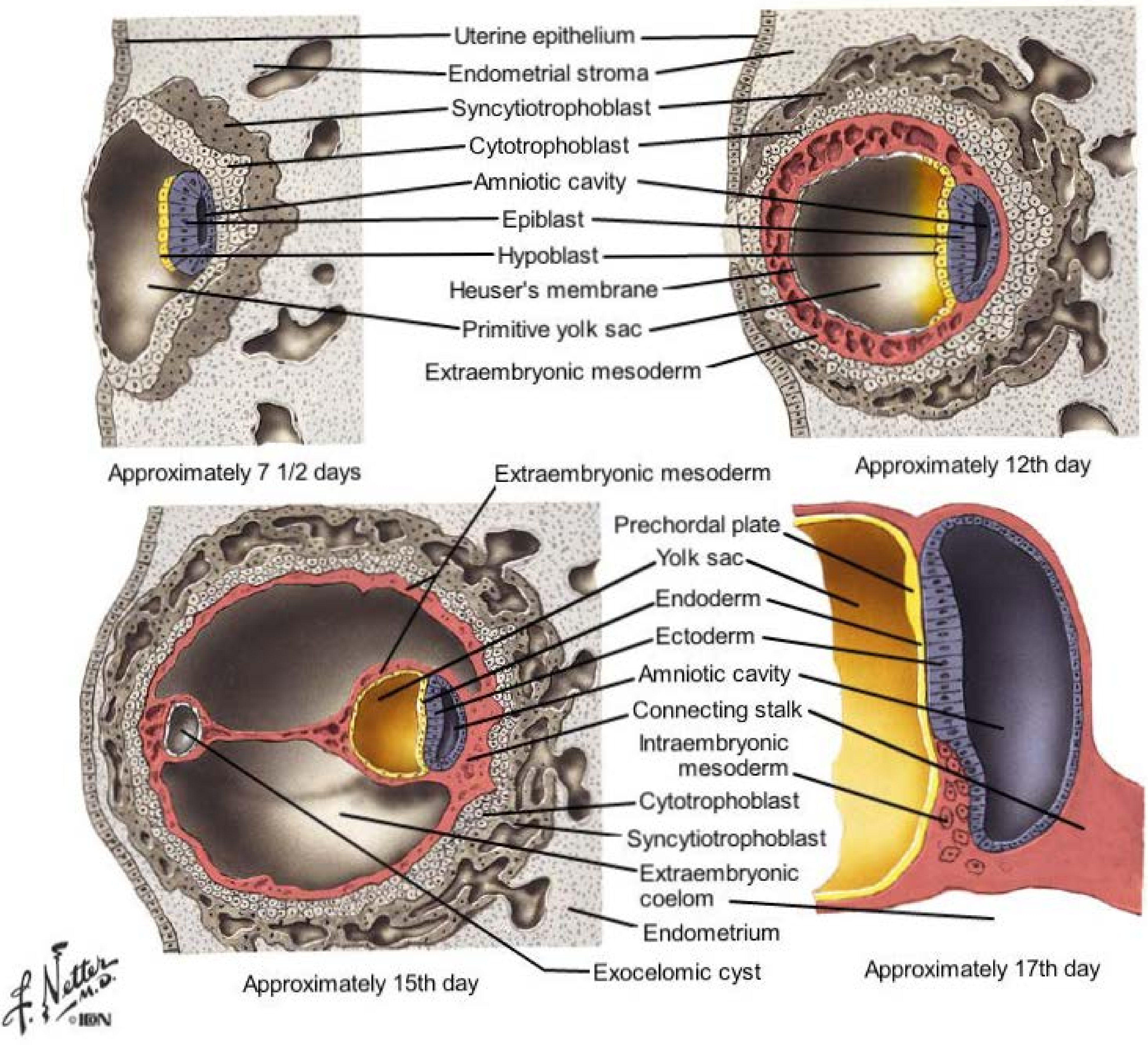
AN OVERVIEW OF DEVELOPMENTAL EVENTS, PROCESSES, AND ABNORMALITIES: TIMELINE



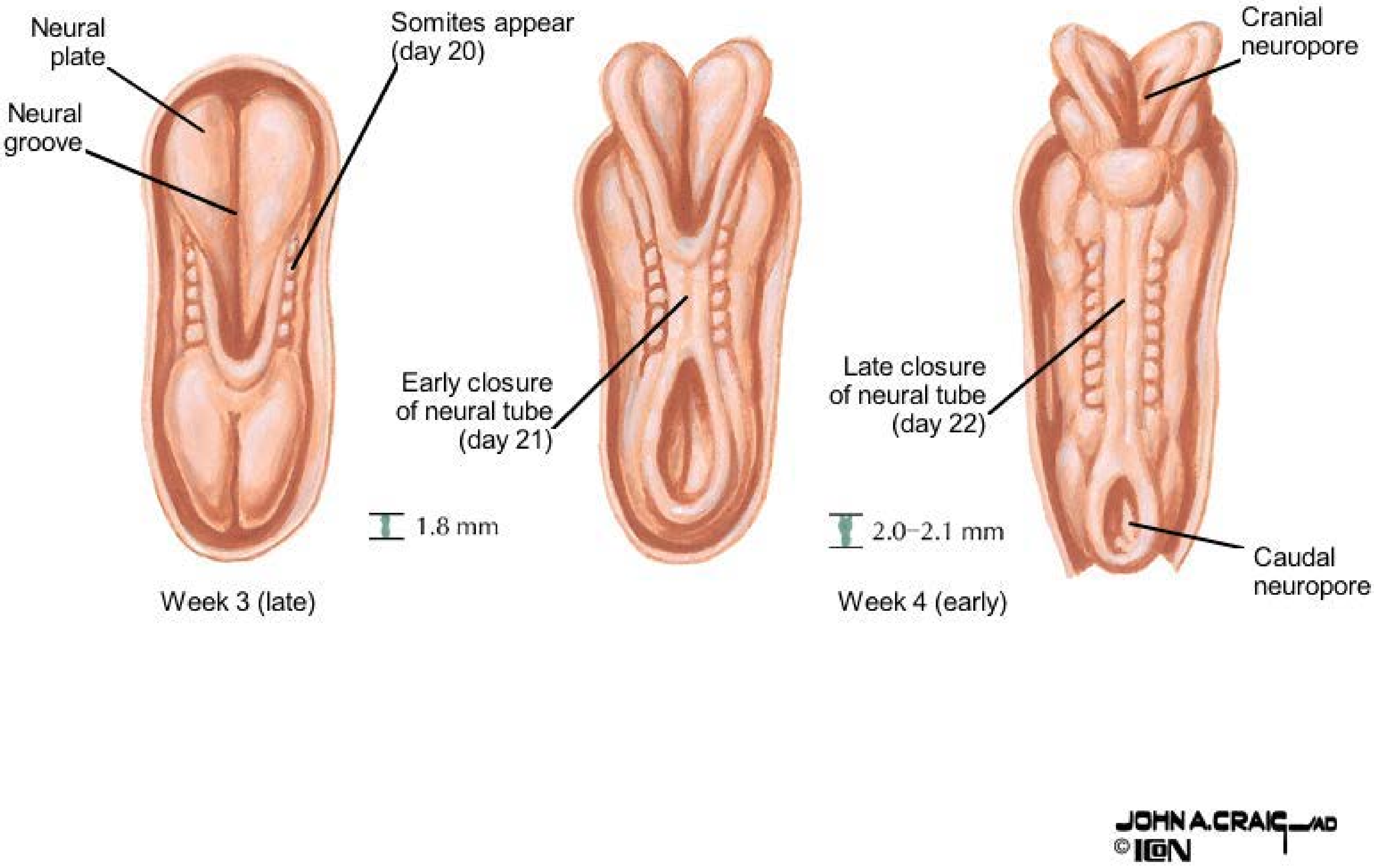
The First Week



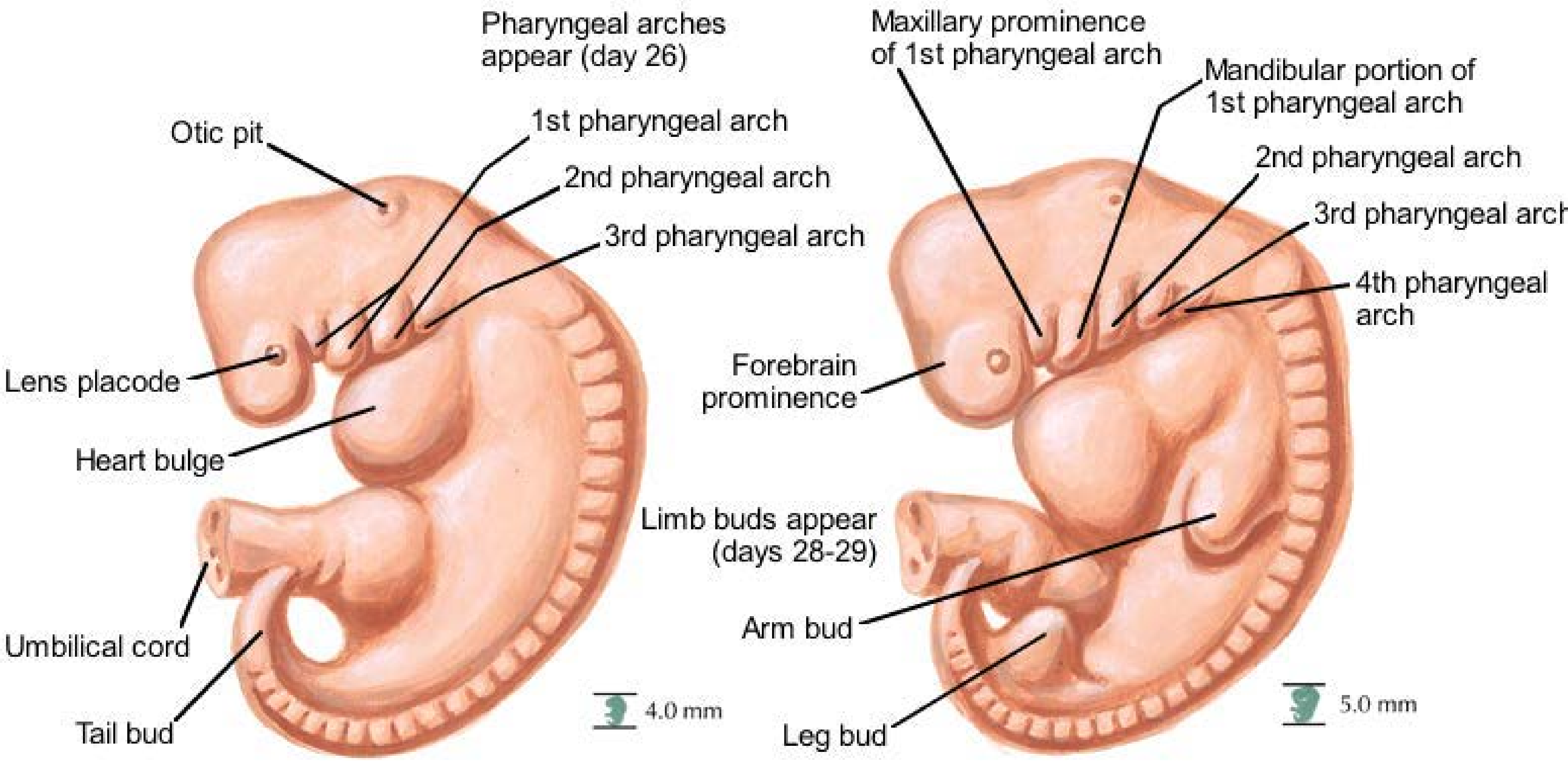
The Second Week



The Embryonic Period
Dorsal Views



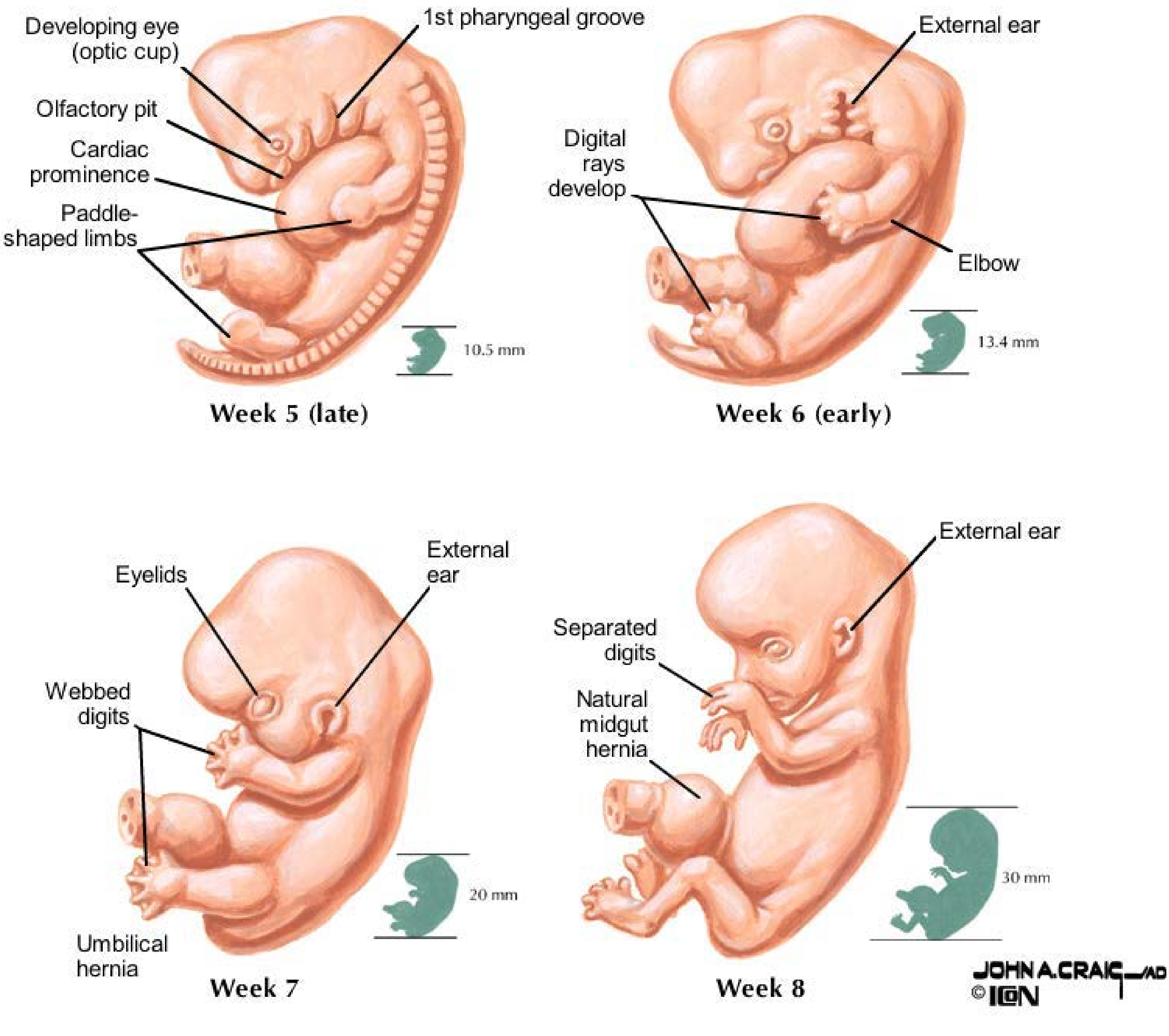
The Embryonic Period
Sagittal Views



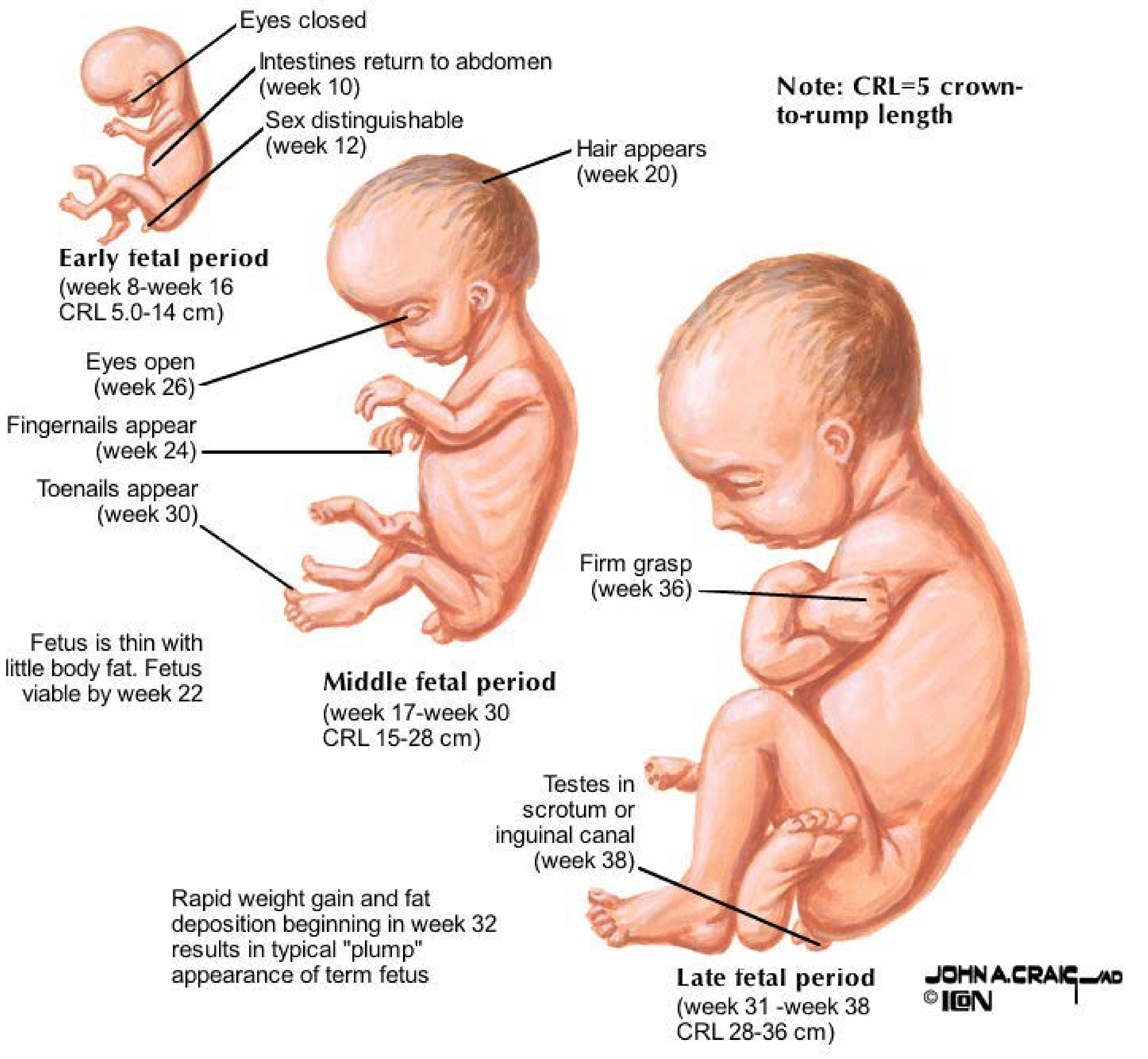
Week 4 (middle)

Week 4 (late)

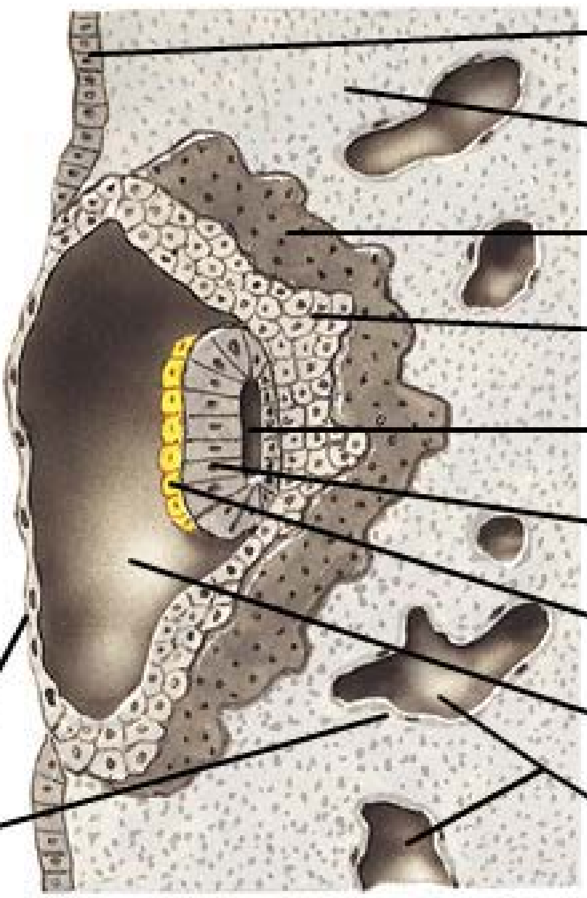
The Embryonic Period



The Fetal Period

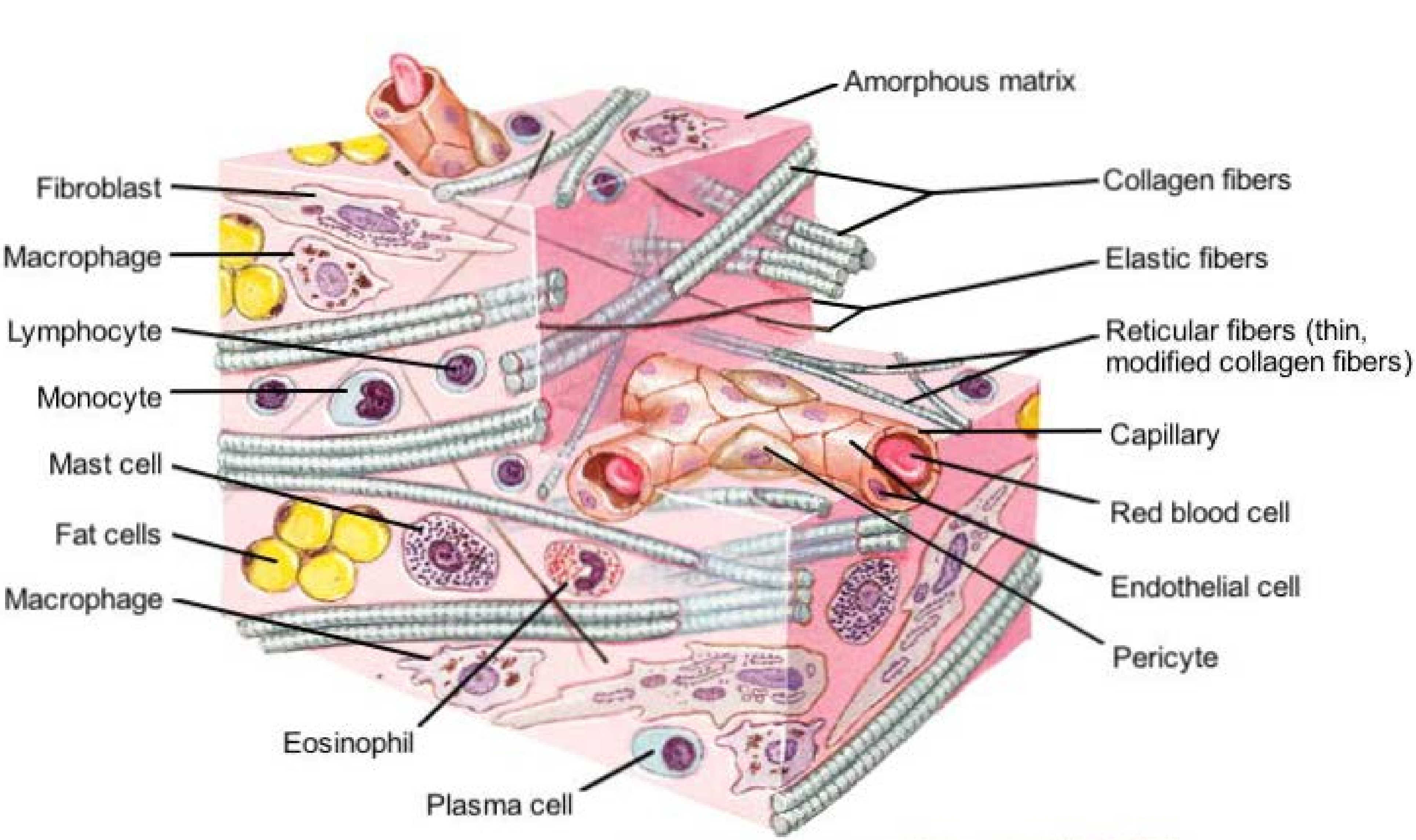


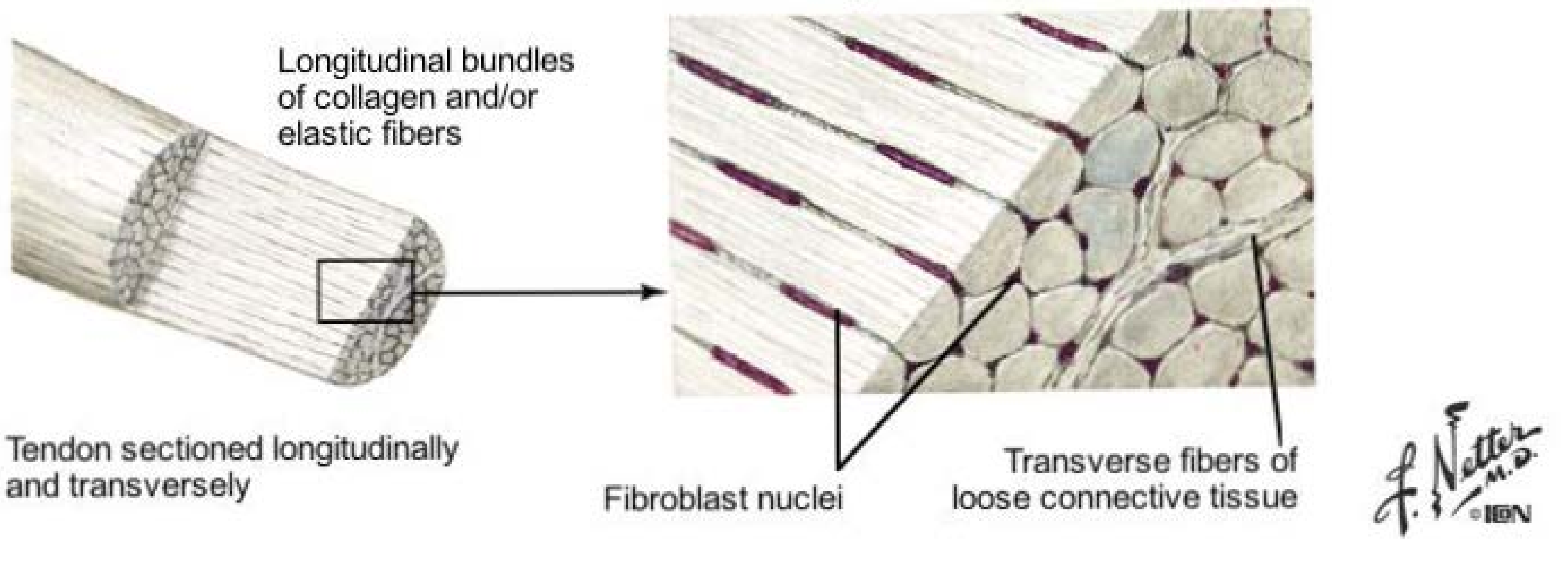
Histological Concepts
Blastocyst with embryo within the uterine mucosa



Approximately 7 1/2 days

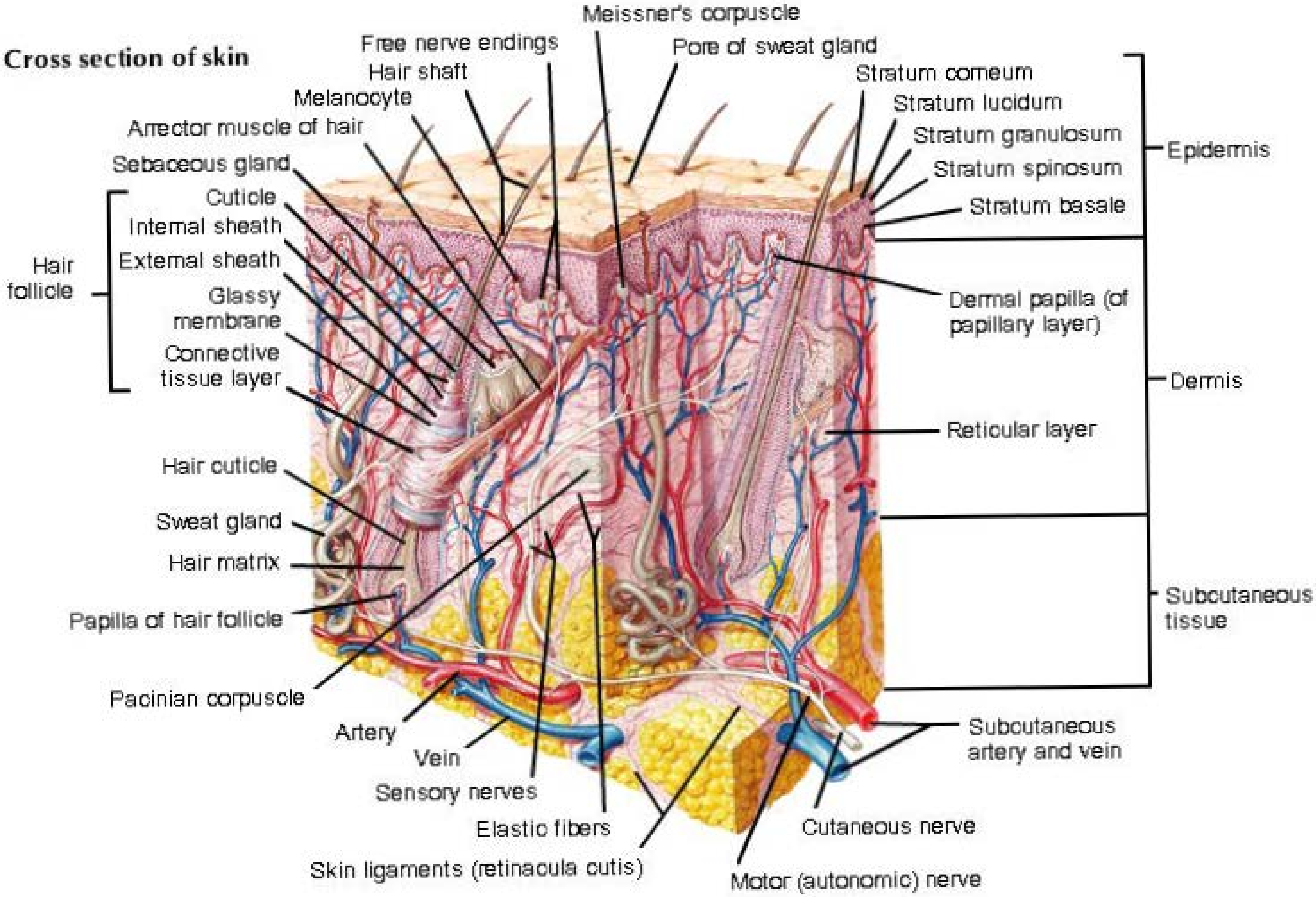
Histological Concepts
Loose and dense connective tissue



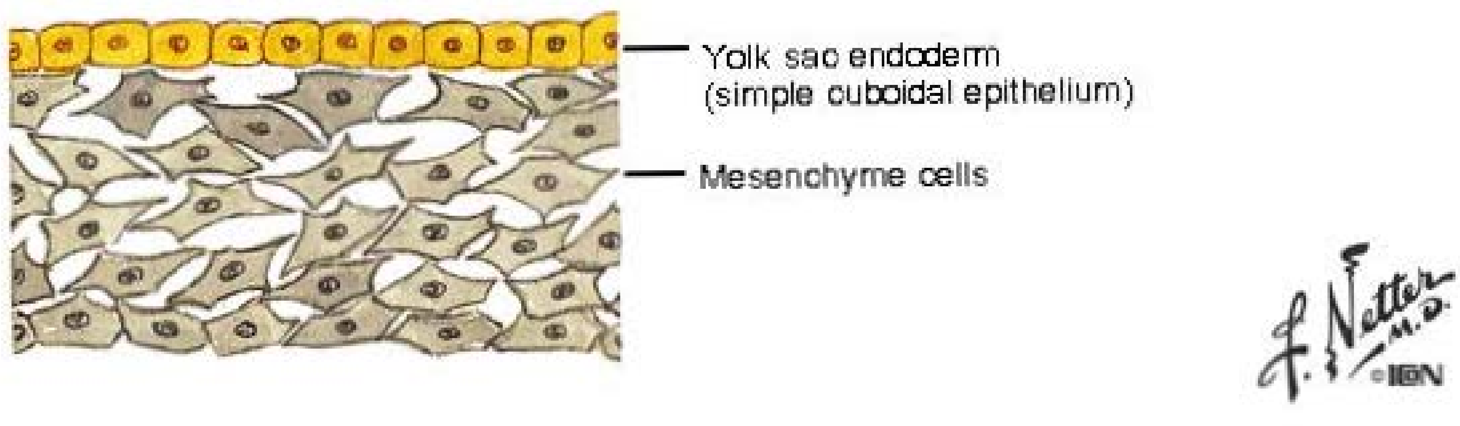


Histological Concepts

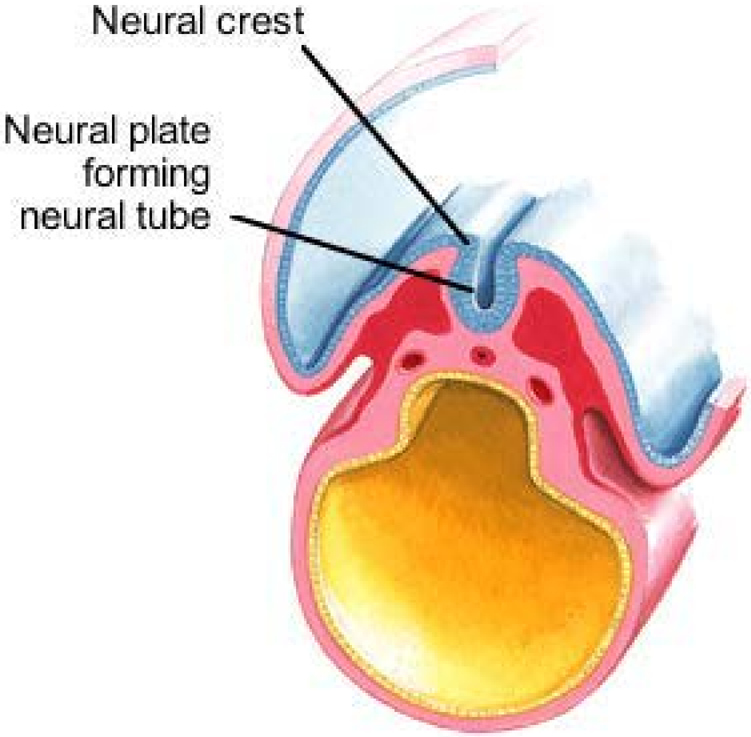
Cross section of skin

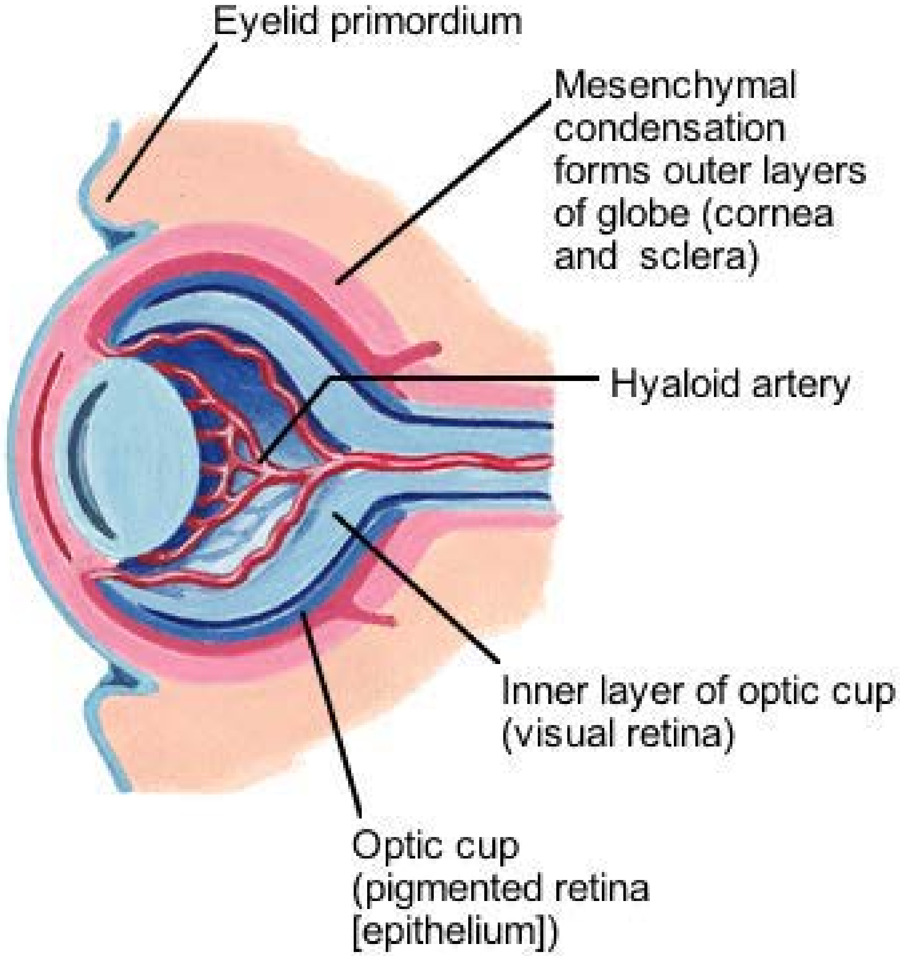


Wall of the yolk sac

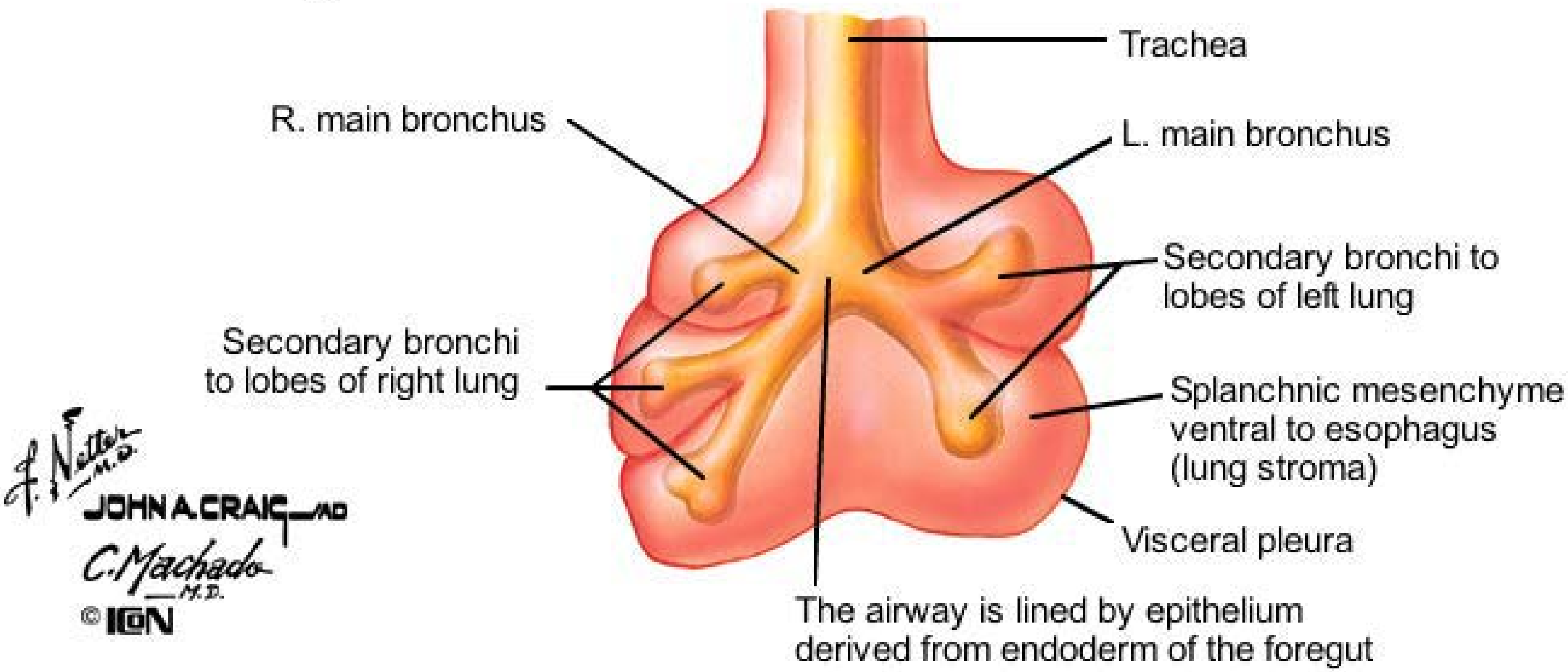


Induction



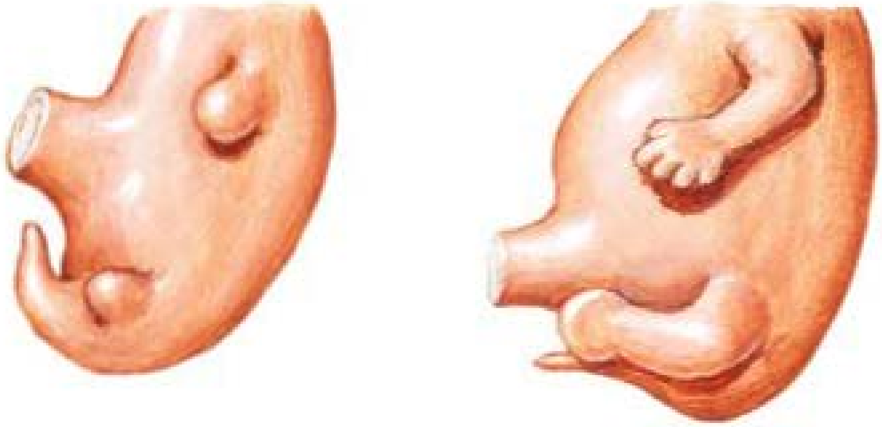


Bronchi and lungs at 5 to 6 weeks

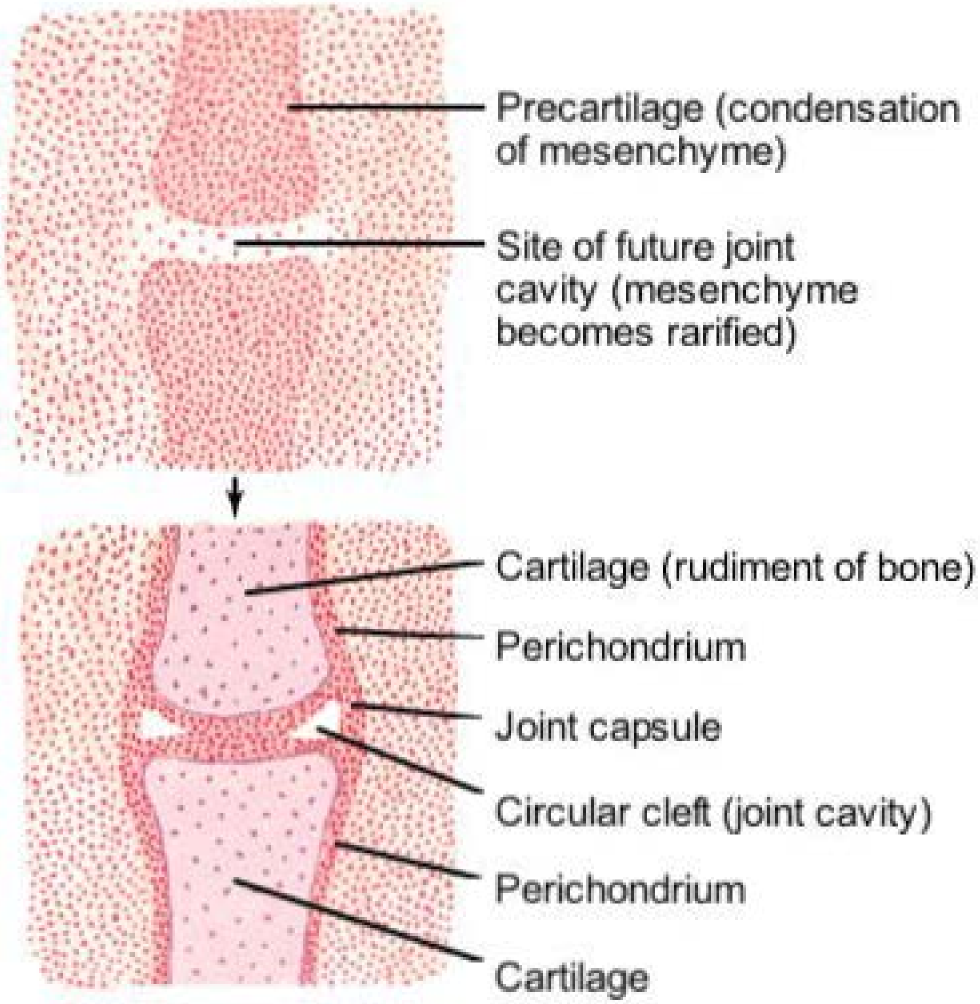


Apoptosis

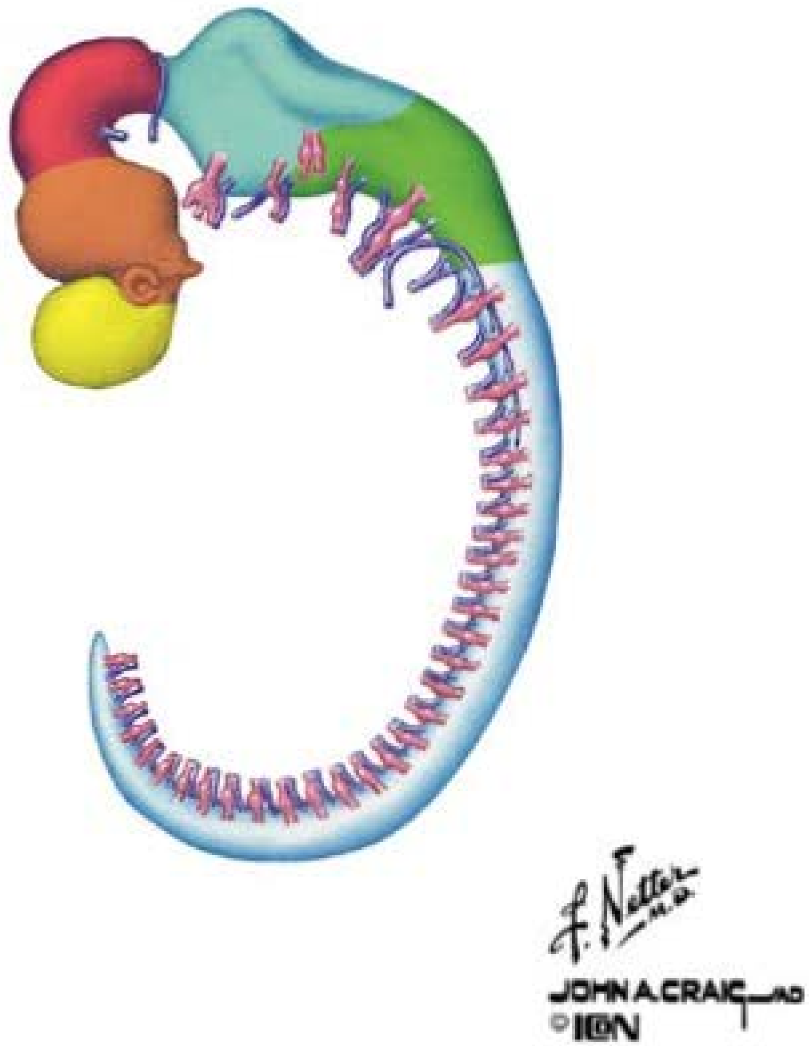
Upper and lower limb buds at 5 and 6 weeks



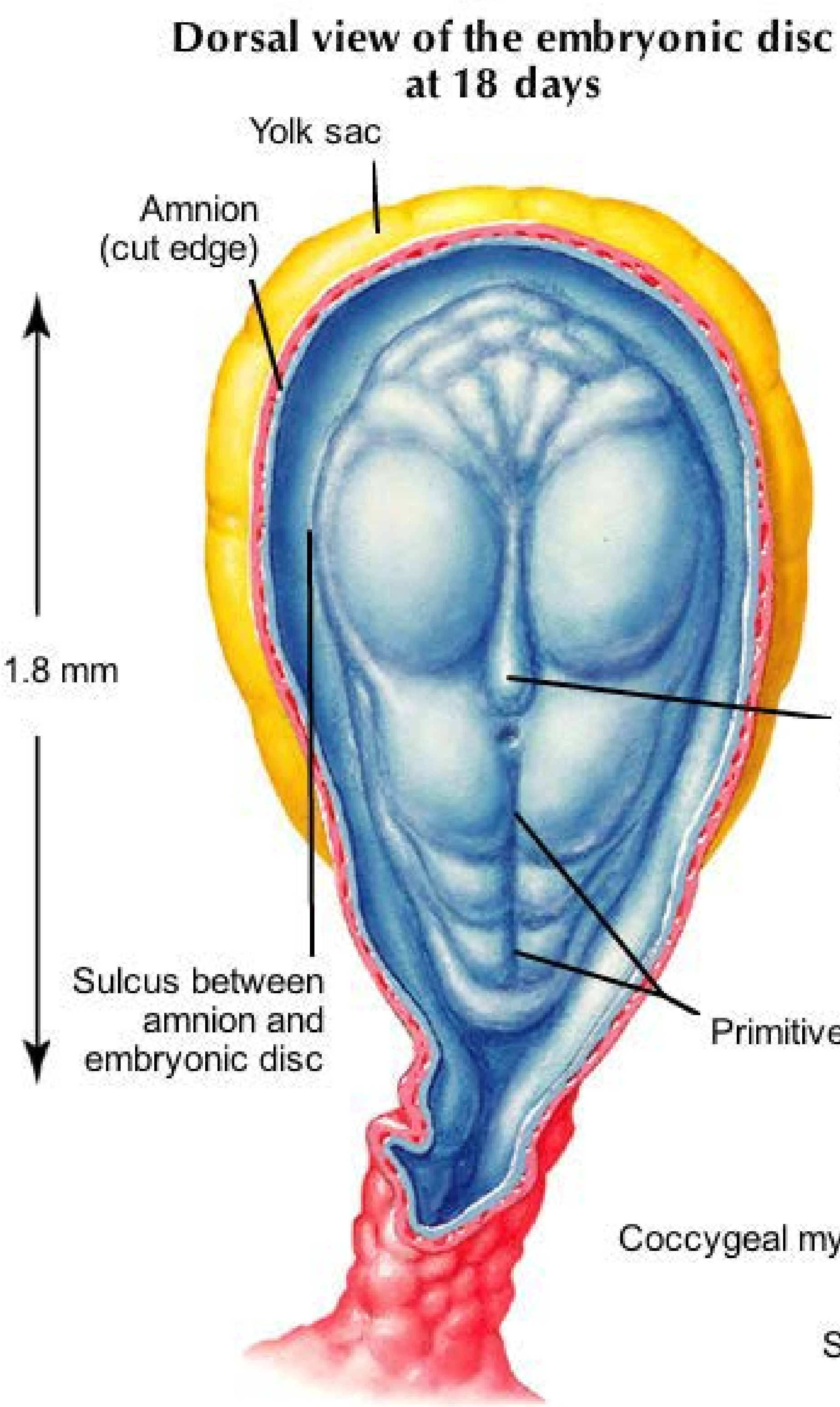
Formation of a joint cavity between two developing bones

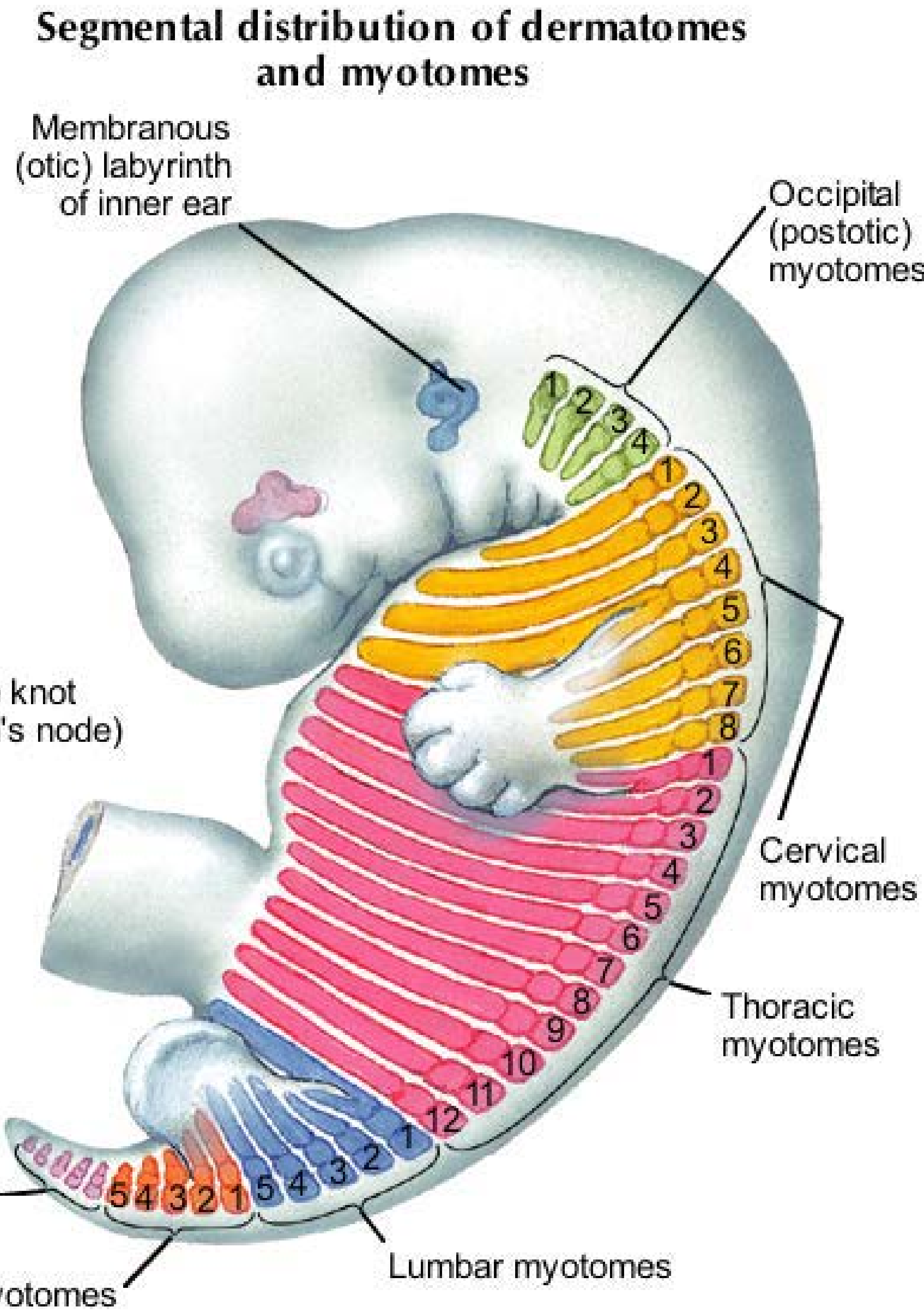


Cranial and spinal nerves at 36 days



Segmentation and Early Pattern Formation

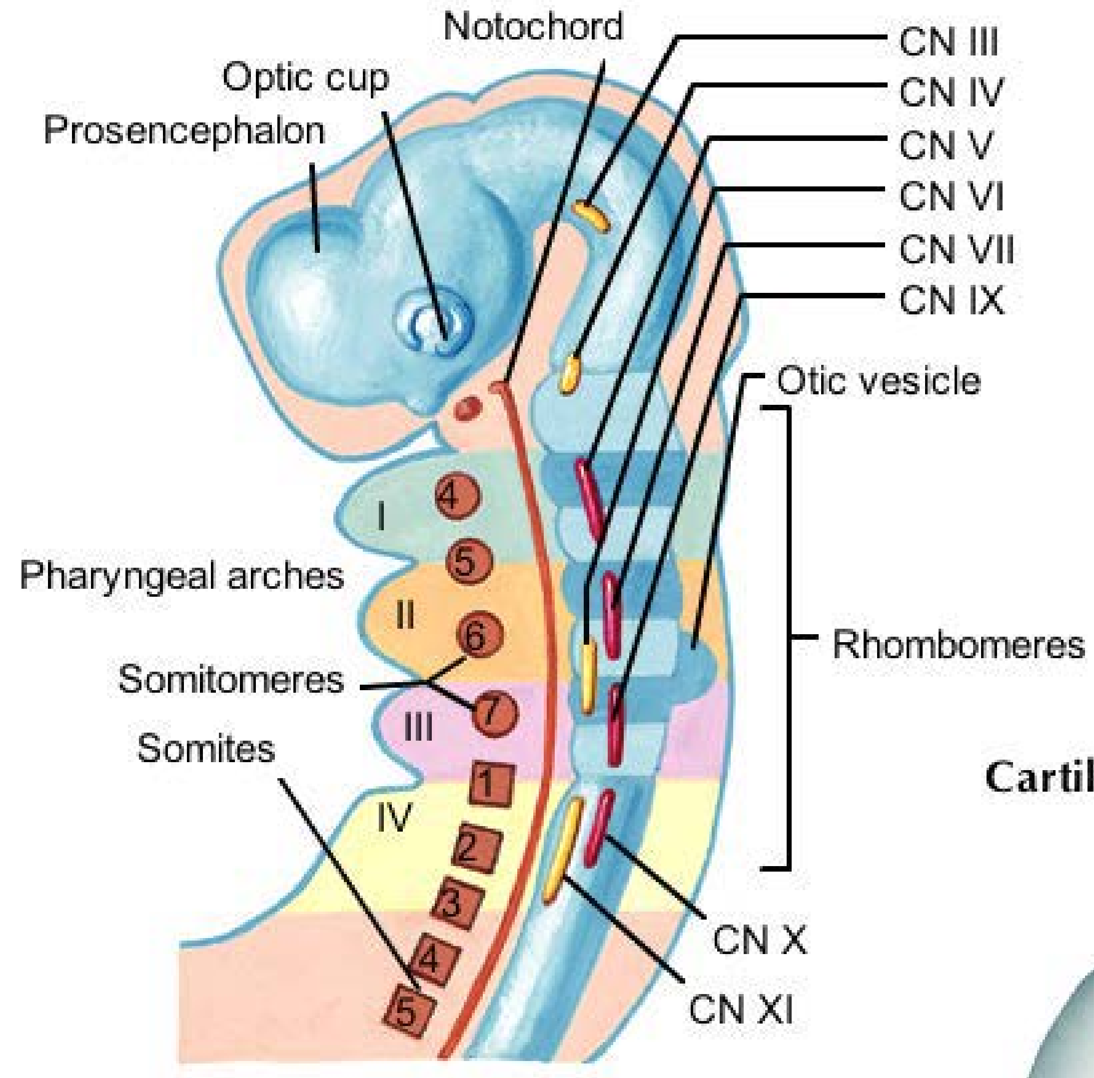




Region of each trunk myotome also represents territory of dermatome into which motor and sensory fibers of segmental spinal nerve extend

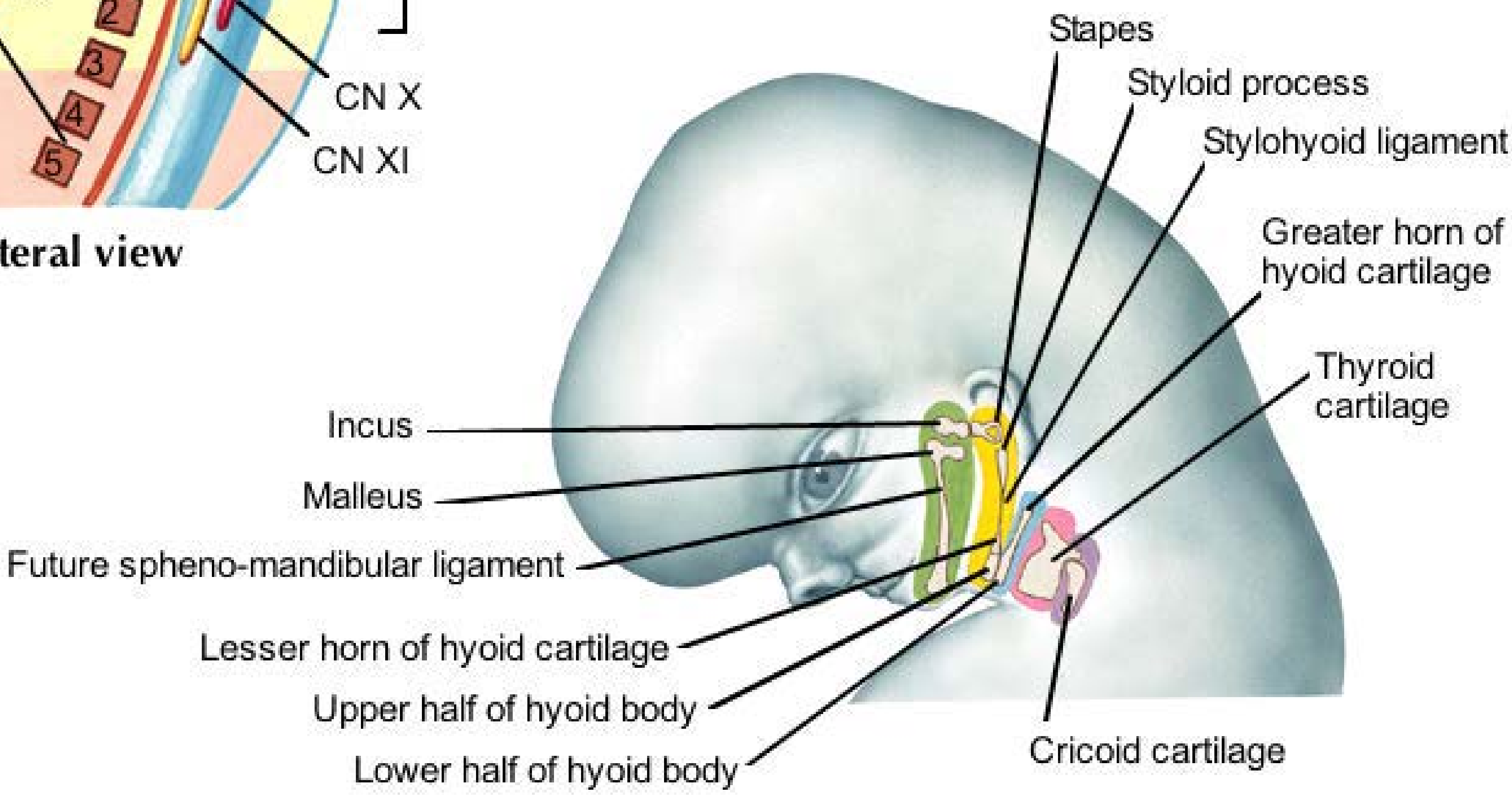
Segmentation and Early Pattern Formation

Segmentation in the head



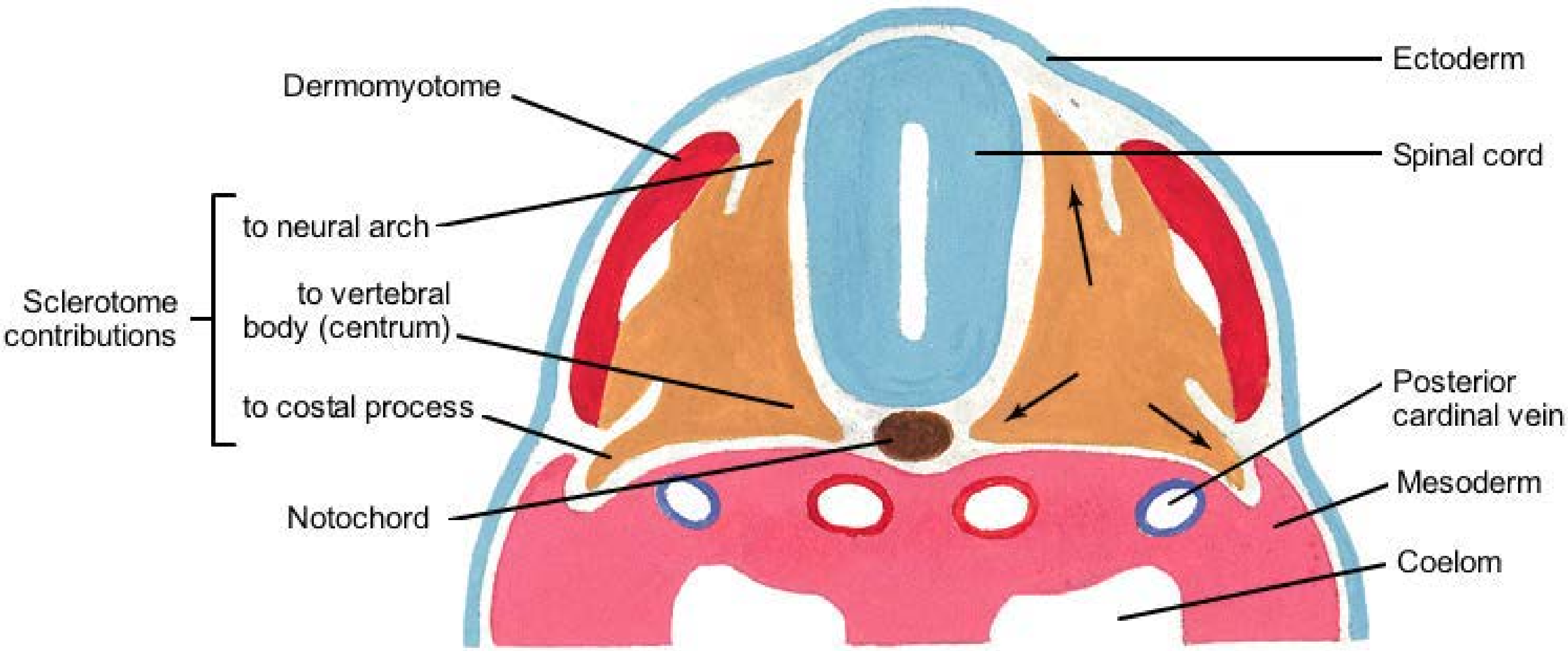
Lateral view

Cartilage derivatives of the pharyngeal arches

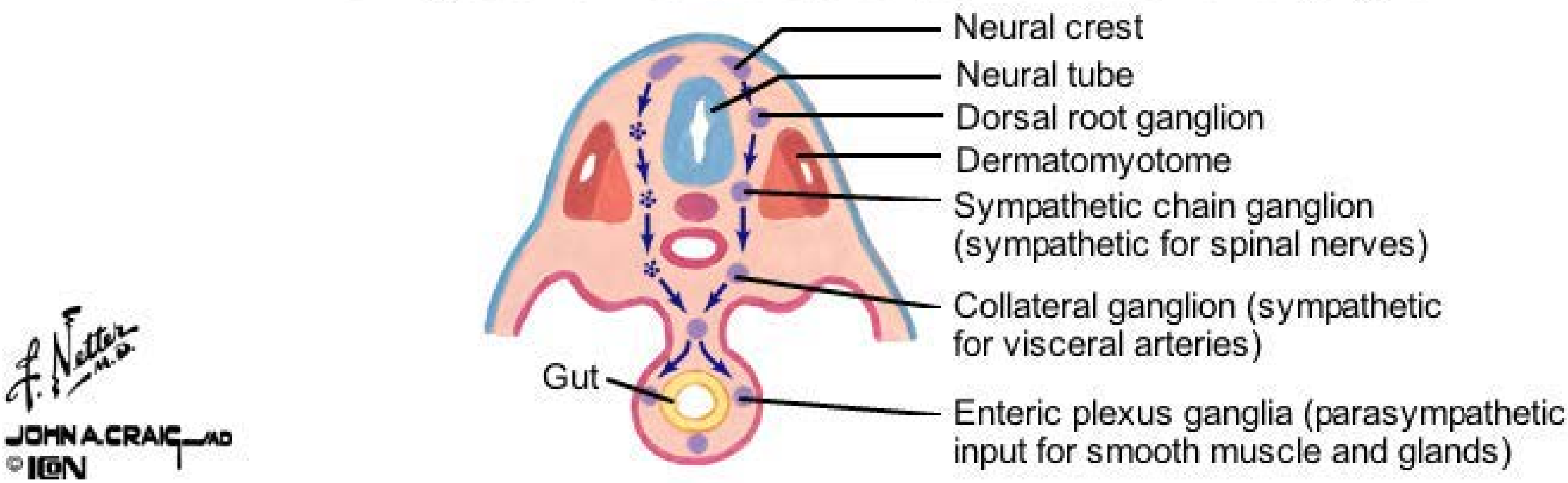


Cell Adhesion and Cell Migration

Somite sclerotome cells dispersing to surround the neural tube in the formation of the vertebral column



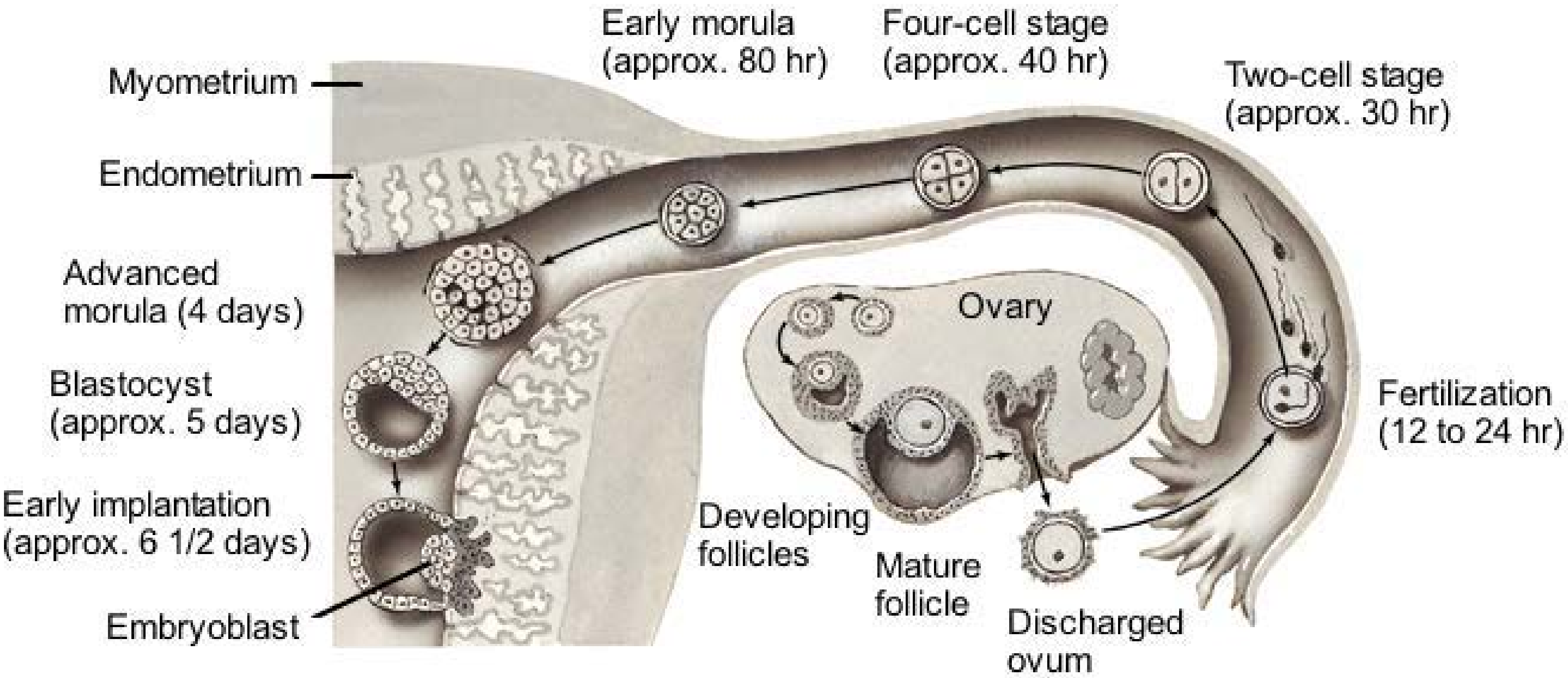
The migration of neural crest cells to form autonomic ganglia



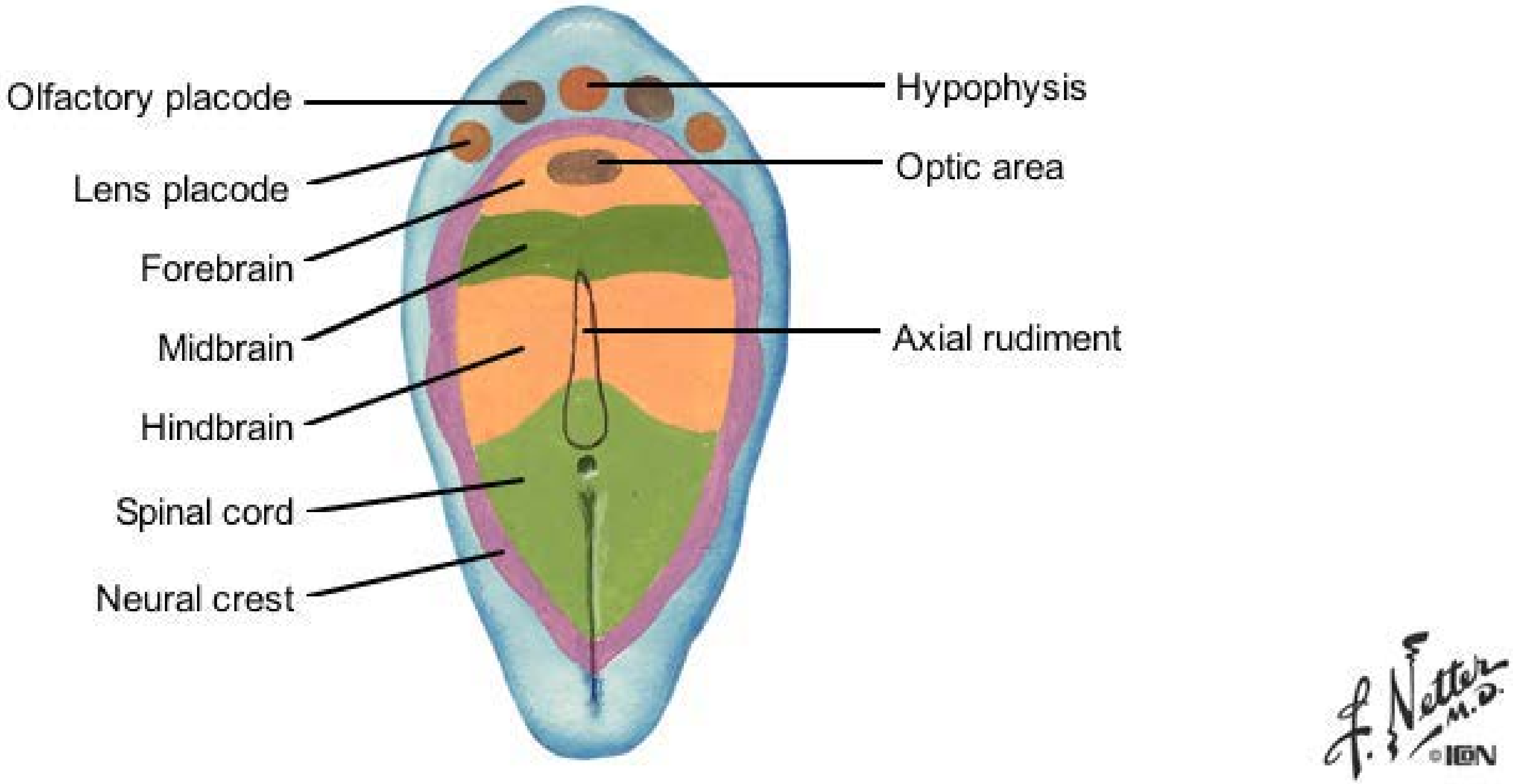
Migration of neural crest cells form peripheral ganglia of autonomic nervous system

Cell Differentiation and Cell Fates

The first week of development

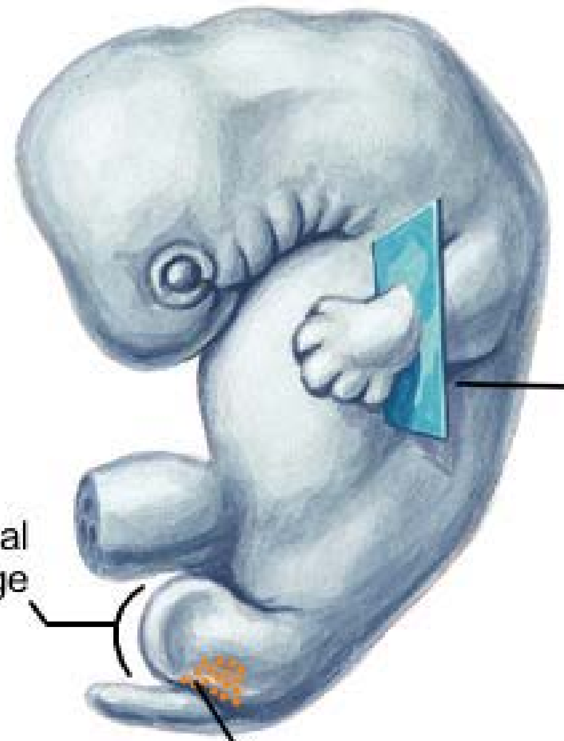


Cellular fate map of the embryonic disc showing ectodermal contributions to the future nervous system



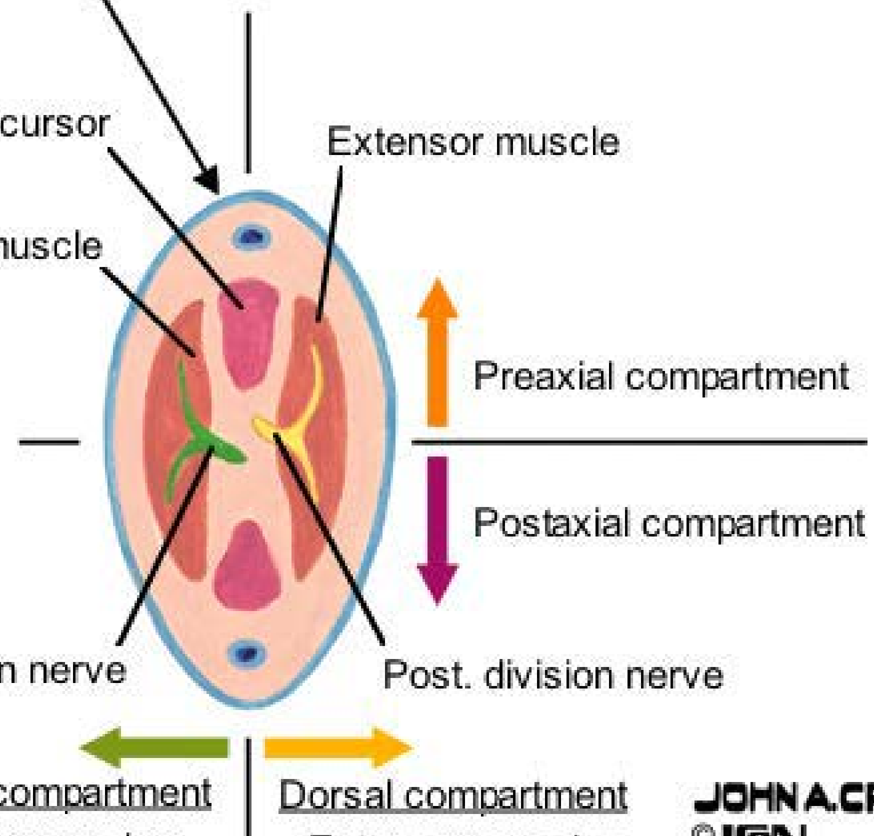
Growth Factors

Limb buds in 6-week embryo



Growth factors that influence limb morphology:

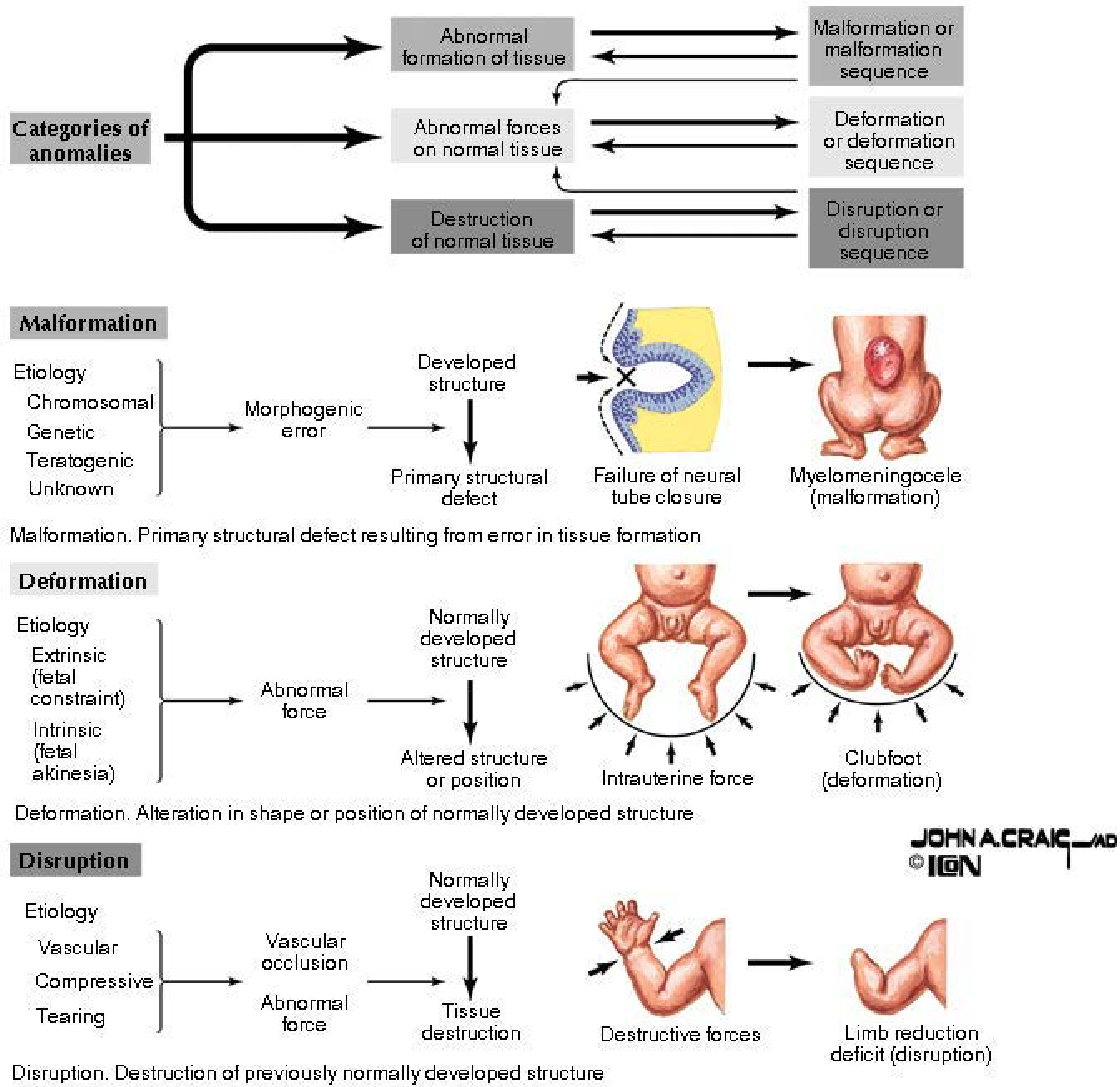
Fibroblast growth factor-8 (FGF-8)-limb bud initiation
Retinoic acid-limb bud initiation
FGF-2, 4, and 8-outgrowth of the limbs
Bone morphogenetic proteins-apoptosis of cells between digits
Sonic hedgehog-establishment of craniocaudal limb axes
Wnt-7a-dorsal patterning of the limbs
En-1-ventral patterning of the limbs



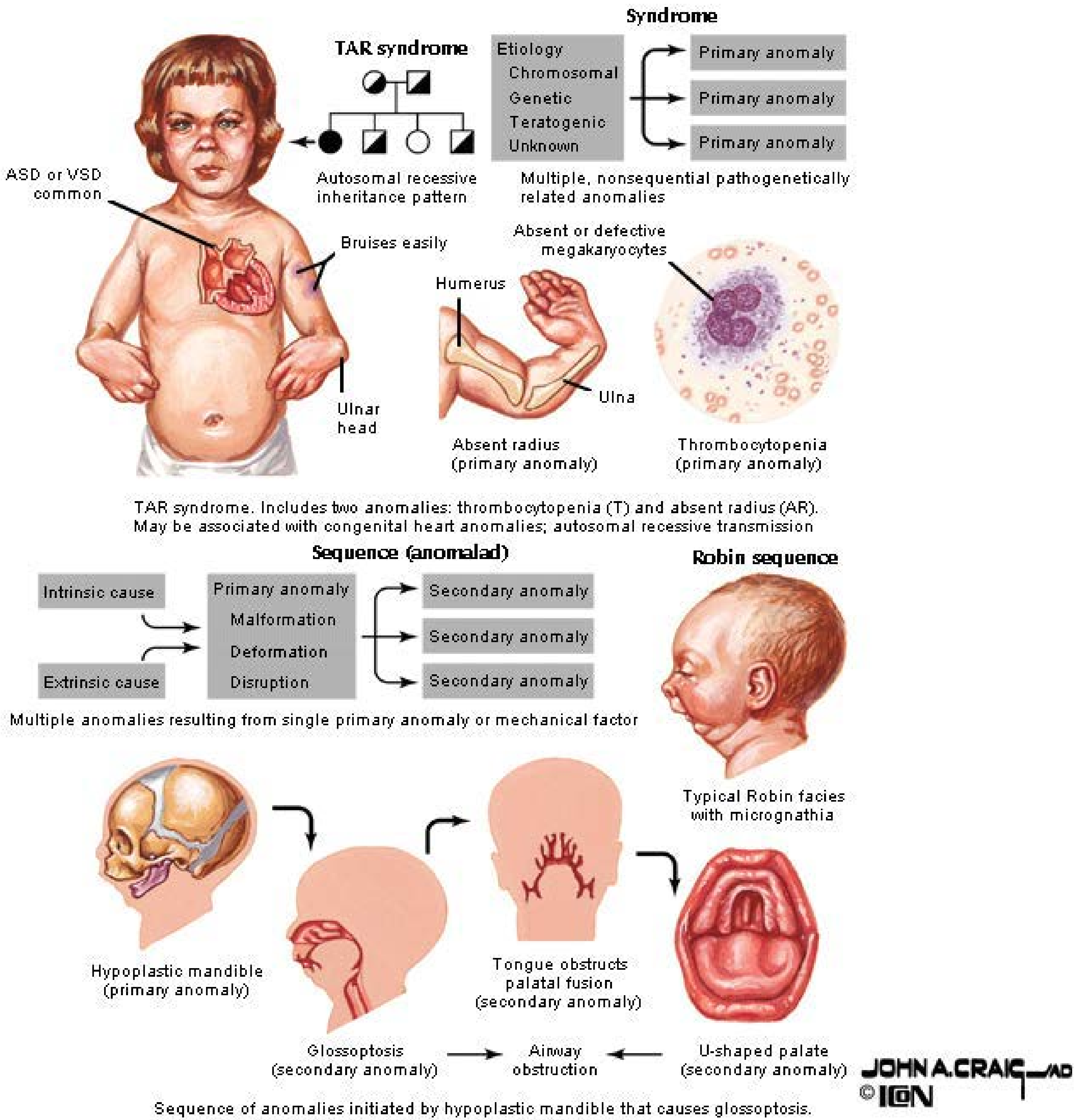
Growth factors that promote tissue development:

Bone morphogenetic protein family-bone development
Indian hedgehog-bone development
Growth/differentiation factor 5-joint formation
Transforming growth factor-β family-myoblast proliferation
Nerve growth factor-sensory and sympathetic neurons
Insulin-like growth factor-1 (IGF-1)-general proliferation of limb mesoderm
Scatter factor (hepatic growth factor)-myotome cell migration in the limbs

Classification of Abnormal Processes
The Classification of Errors of Morphogenesis



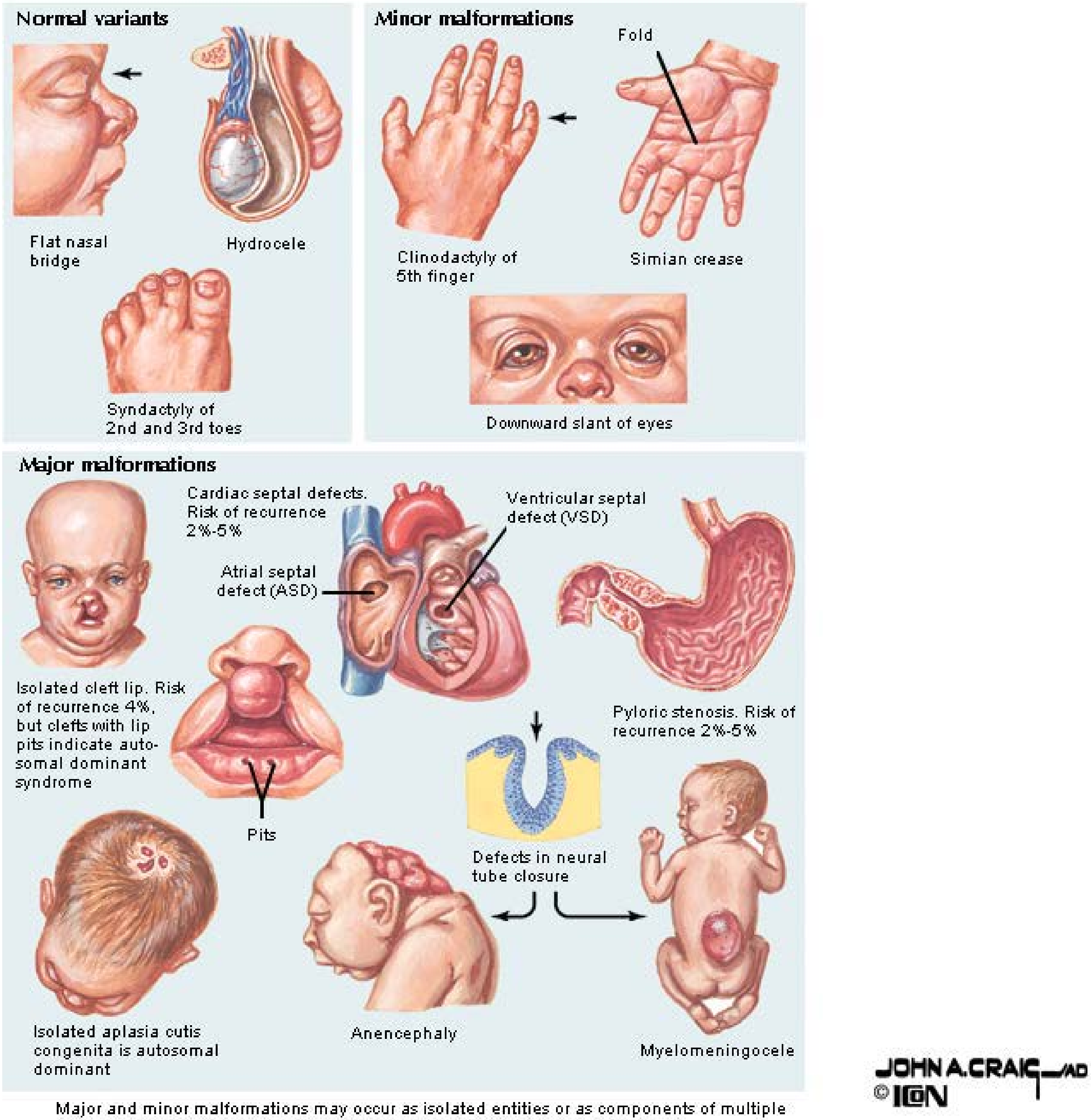
Classification of Multiple Anomalies
Patterns of Multiple Anomalies: Syndrome Versus Sequence



TAR syndrome. Includes two anomalies: thrombocytopenia (T) and absent radius (AR). May be associated with congenital heart anomalies; autosomal recessive transmission

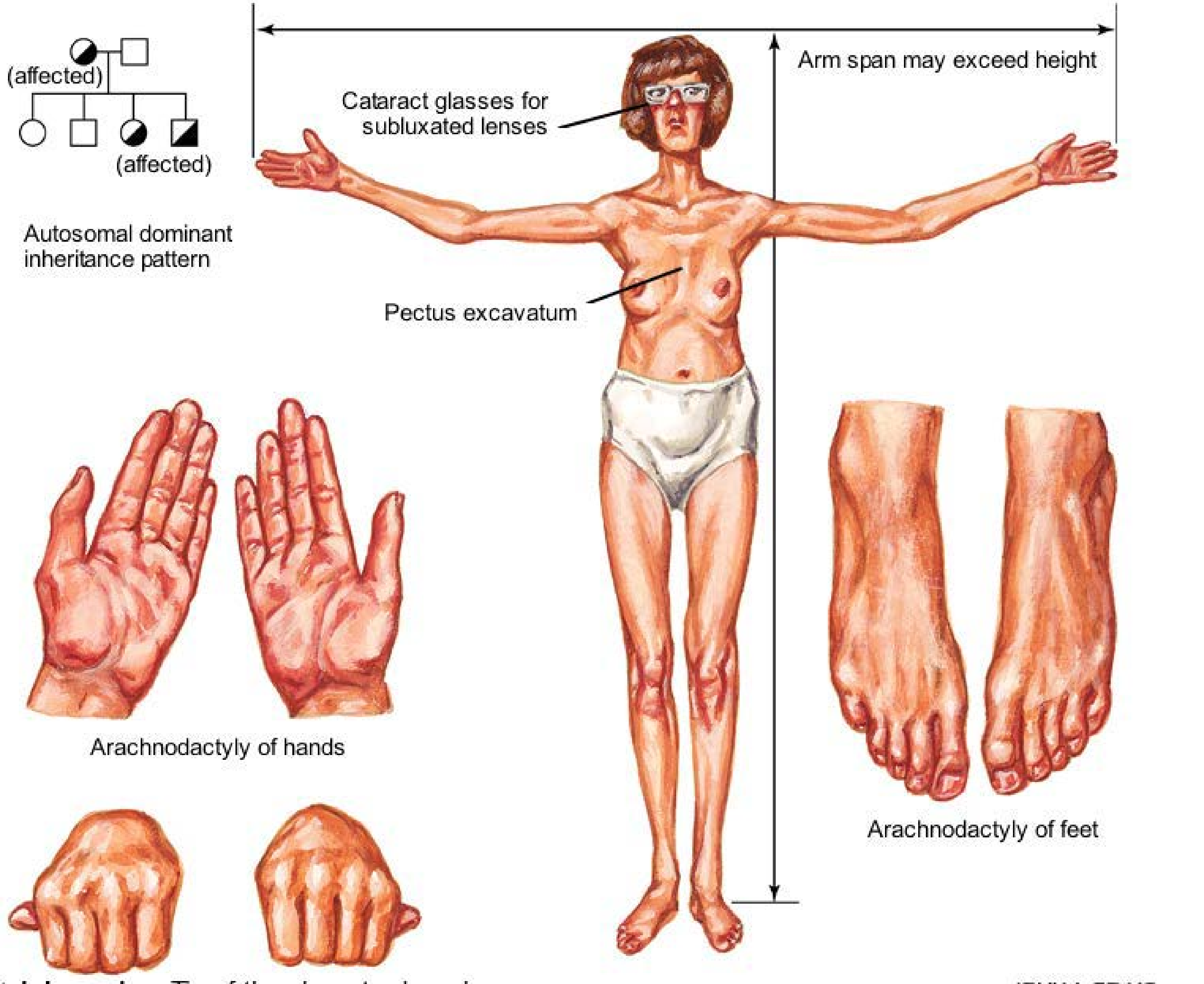
Sequence of anomalies initiated by hypoplastic mandible that causes glossoptosis. Resulting palatal defect with glossoptosis may obstruct airway

Normal Versus Major Versus Minor Malformations
The Classification of Malformations



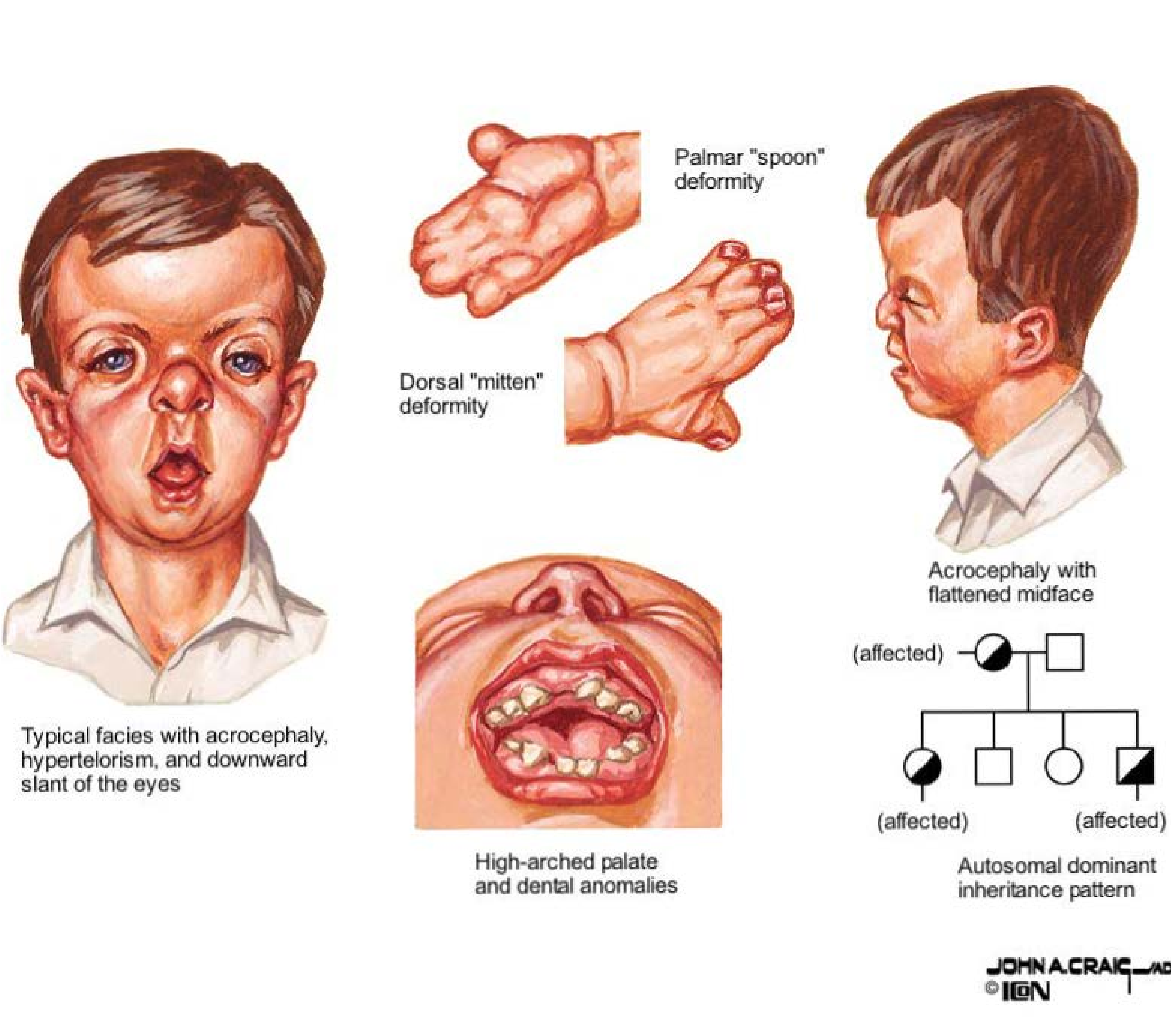
Major and minor malformations may occur as isolated entities or as components of multiple malformation syndrome. Risk of recurrence depends on the cause of the defect

Marfan Syndrome

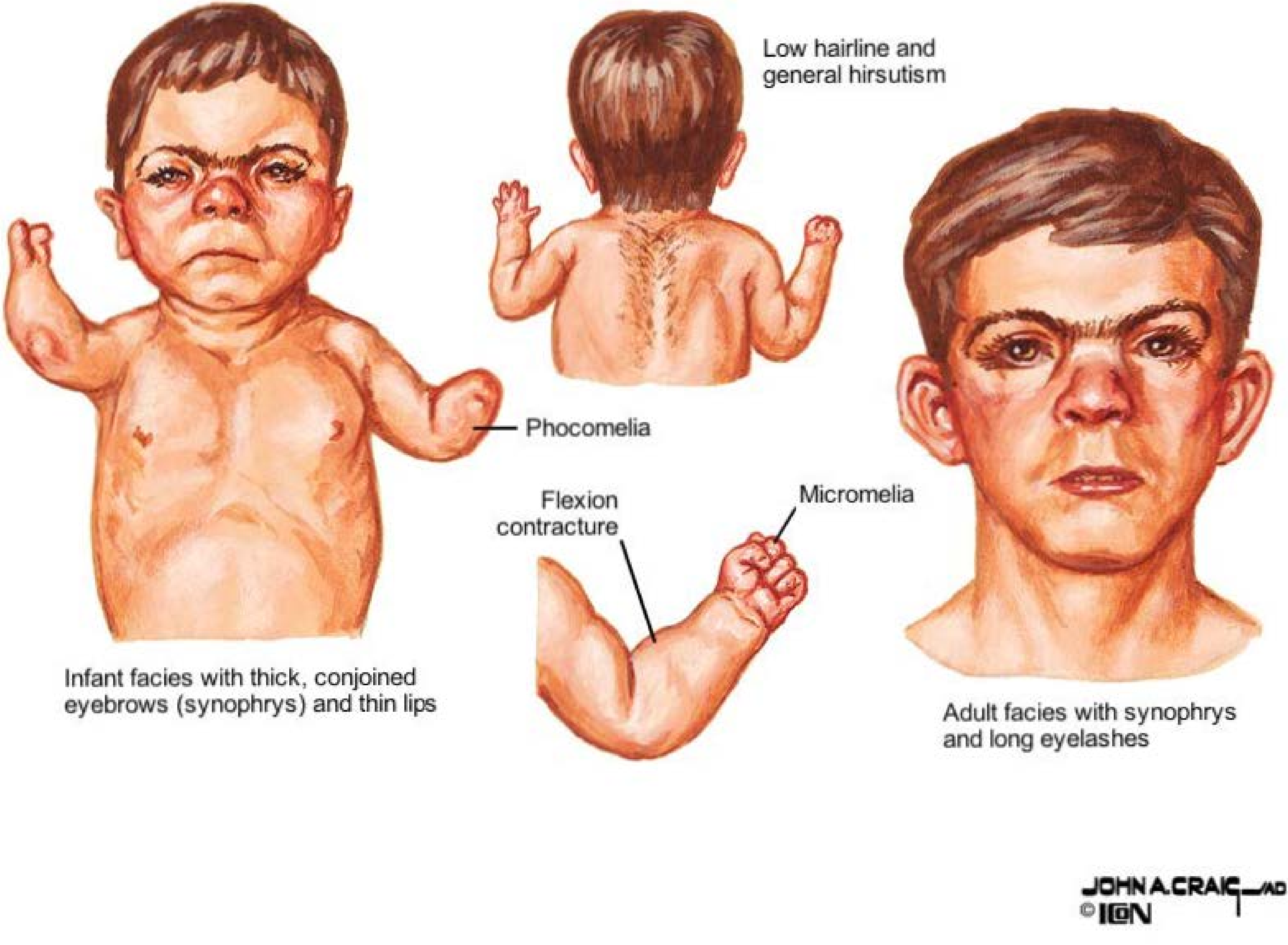


Steinberg sign. Tip of thumb protrudes when thumb folded inside fist. Thumb and index finger overlap when encircling opposite wrist

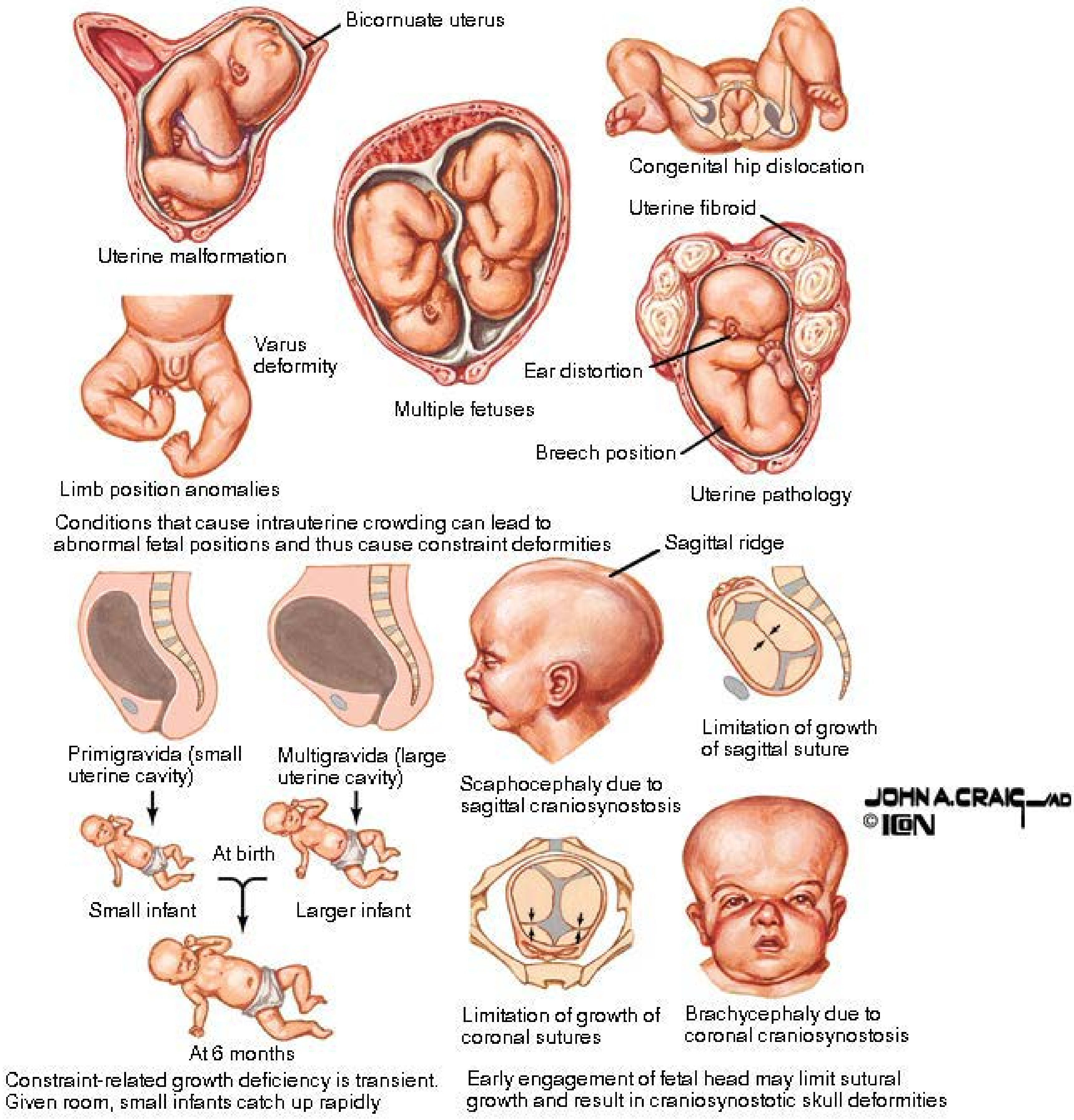
Apert Syndrome



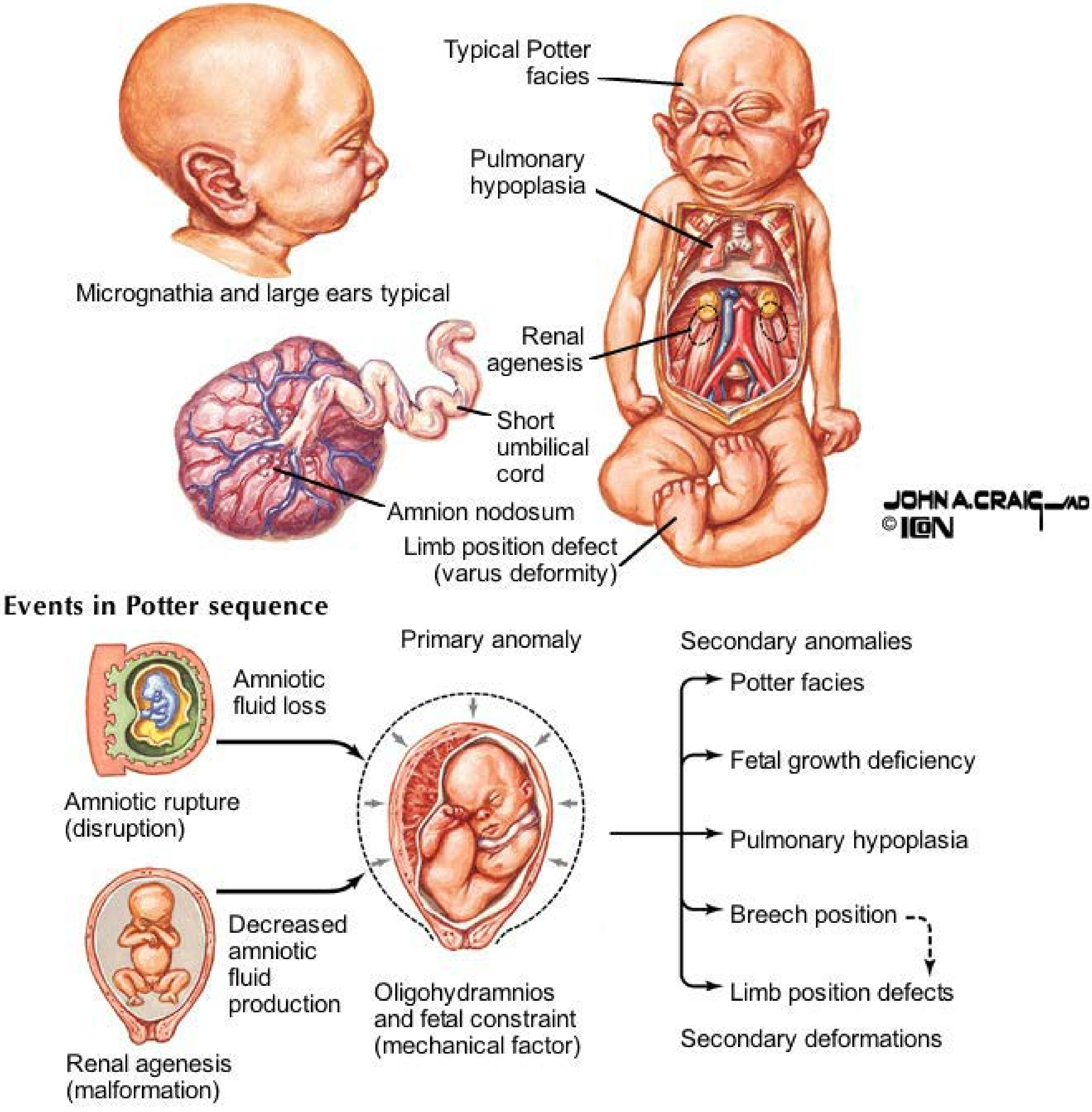
De Lange Syndrome



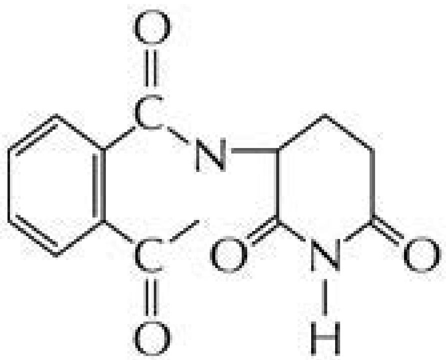
Examples of Deformations



Example of a Deformation Sequence
Potter Sequence

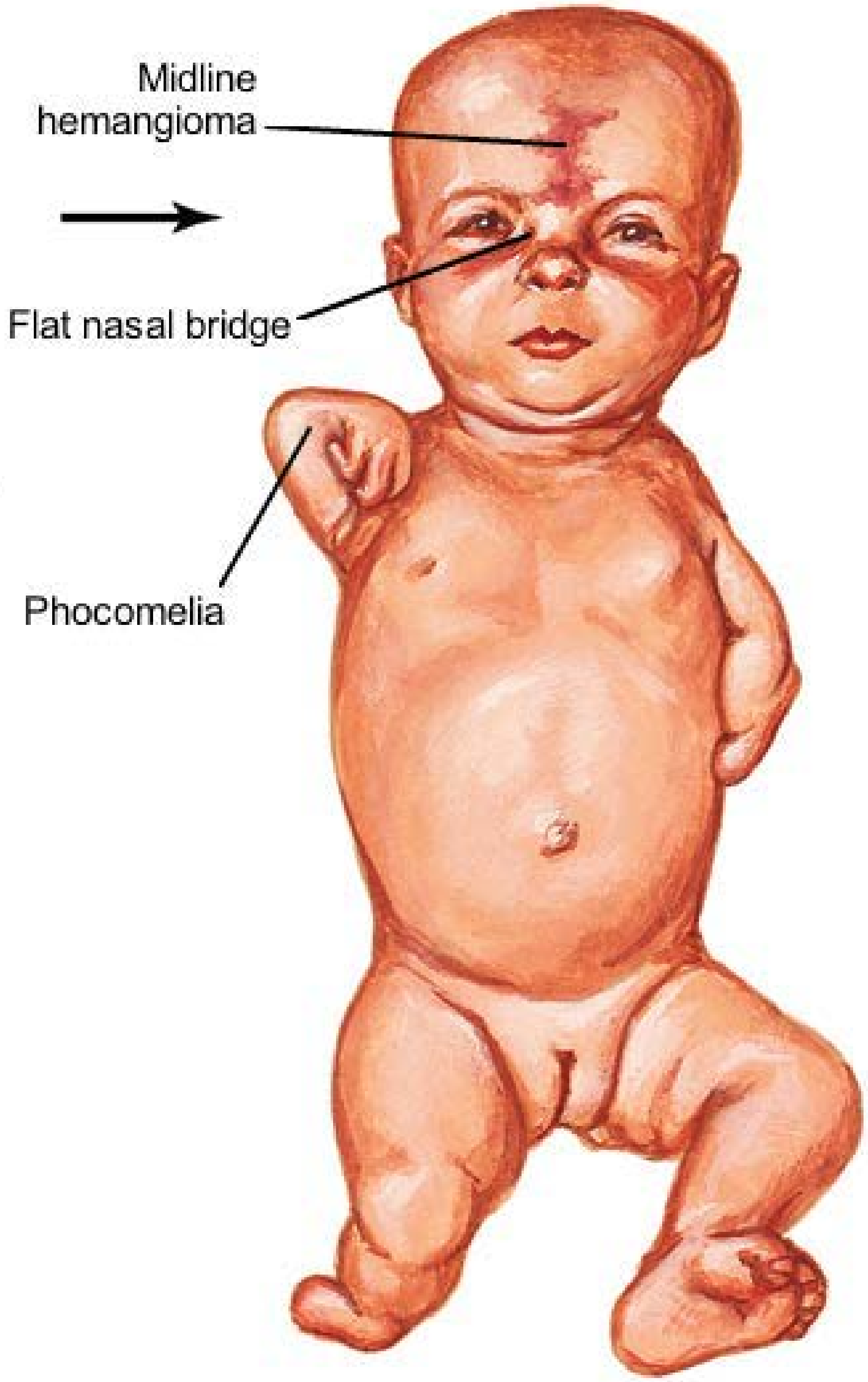


Drug-Induced Embryopathies
Thalidomide



(α[*N*-phthalimido]glutarimide)

27- to 33-day embryo



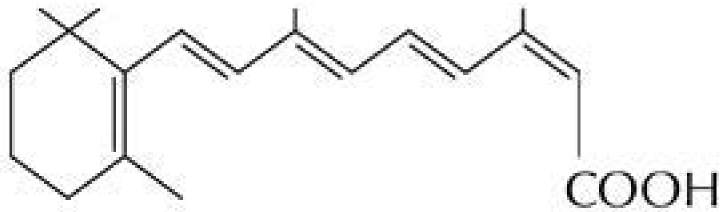
Clinical features of
thalidomide embryopathy

Limb defects. From hypoplasia to complete absence of radius, ulna, and humerus; fibula and tibia less commonly involved

Drug-Induced Embryopathies

Retinoic acid

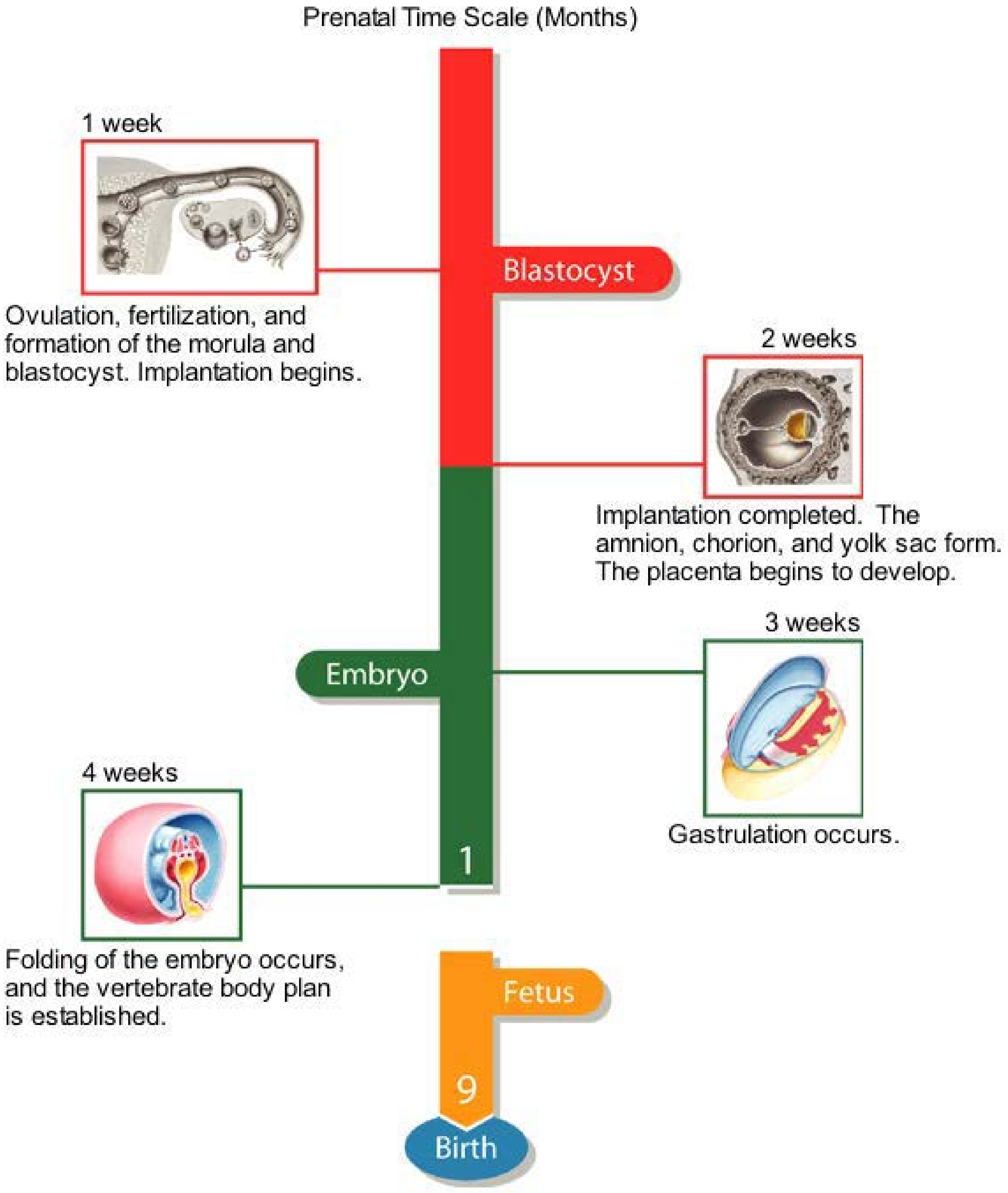
Facial features. Ocular hypertelorism with down-slanting palpebral fissures, micrognathia, and U-shaped palate



(13-*cis*-retinoic acid)

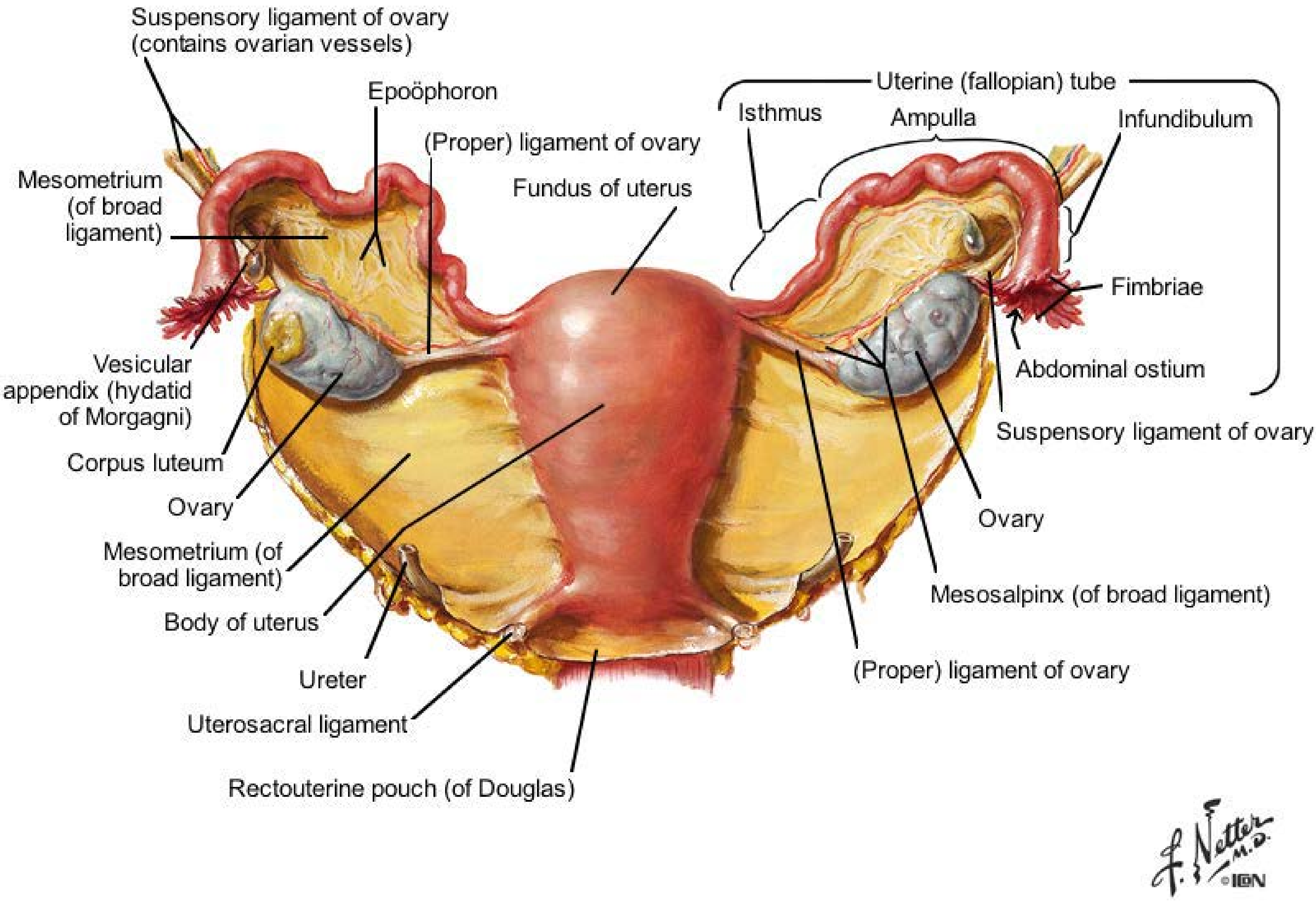
Hydrocephalus may occur

EARLY EMBRYONIC DEVELOPMENT AND THE PLACENTA
TIMELINE

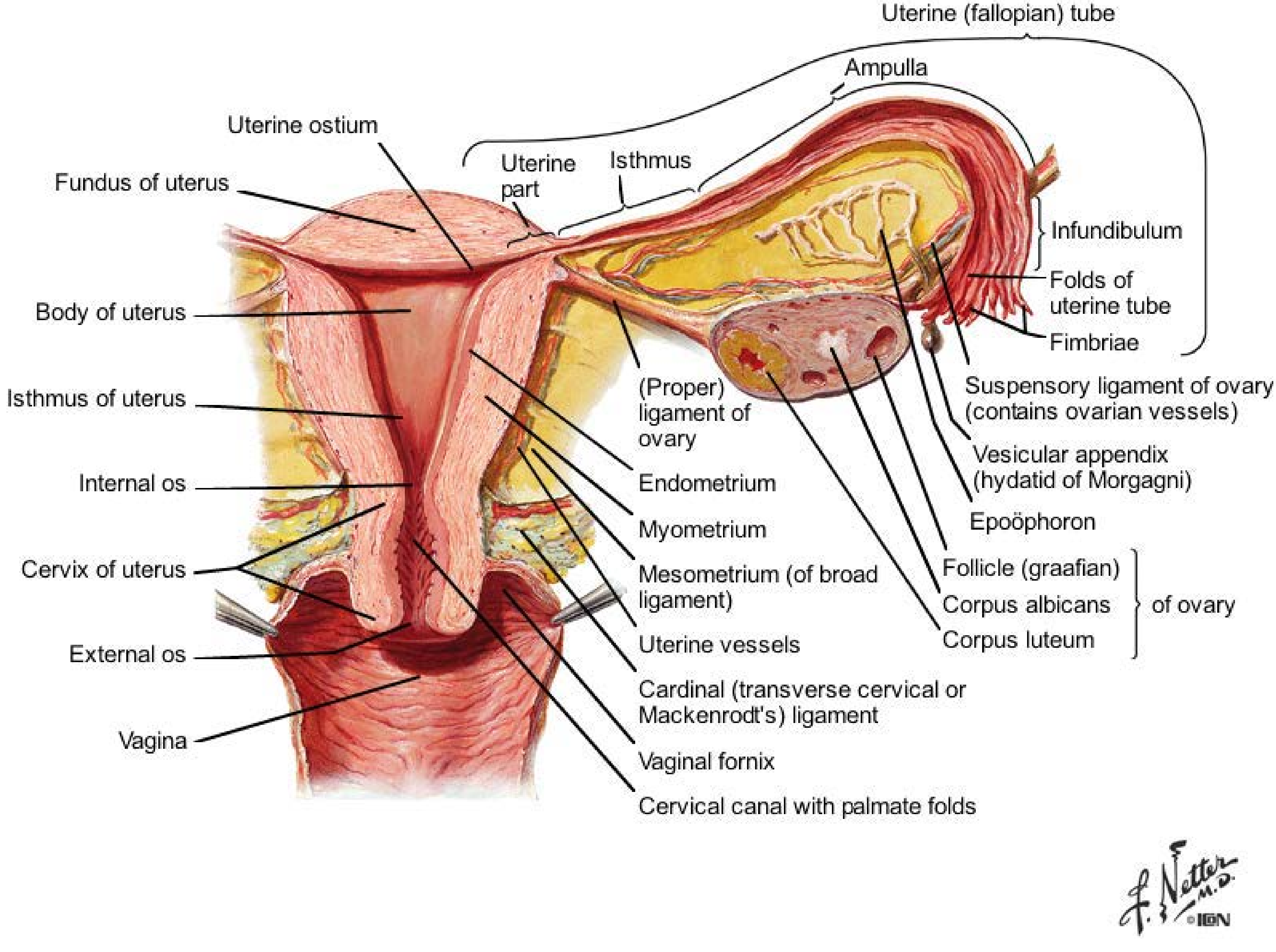


Adult Uterus, Ovaries, and Uterine Tubes

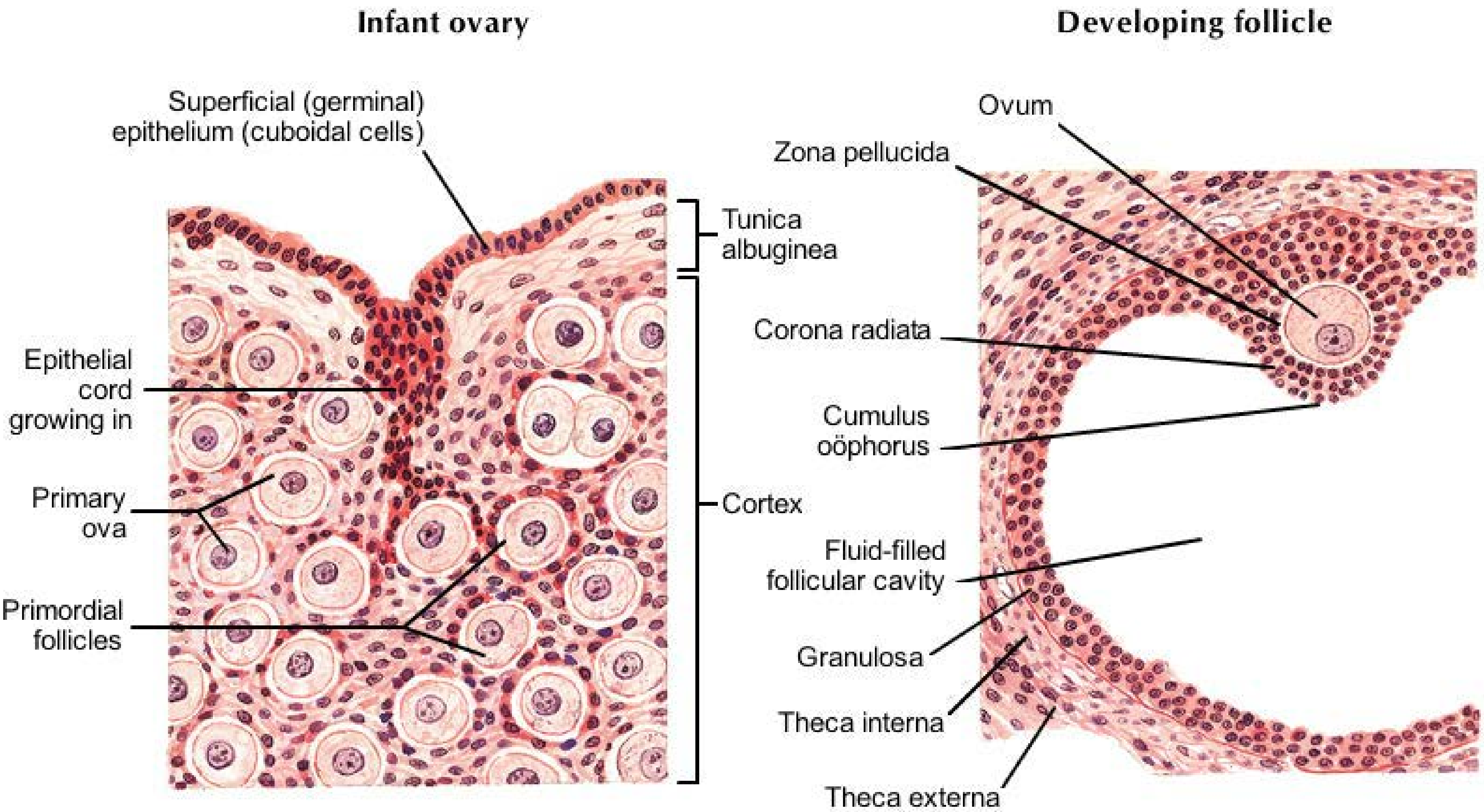
Posterior view



Adult Uterus, Ovaries, and Uterine Tubes
Frontal section

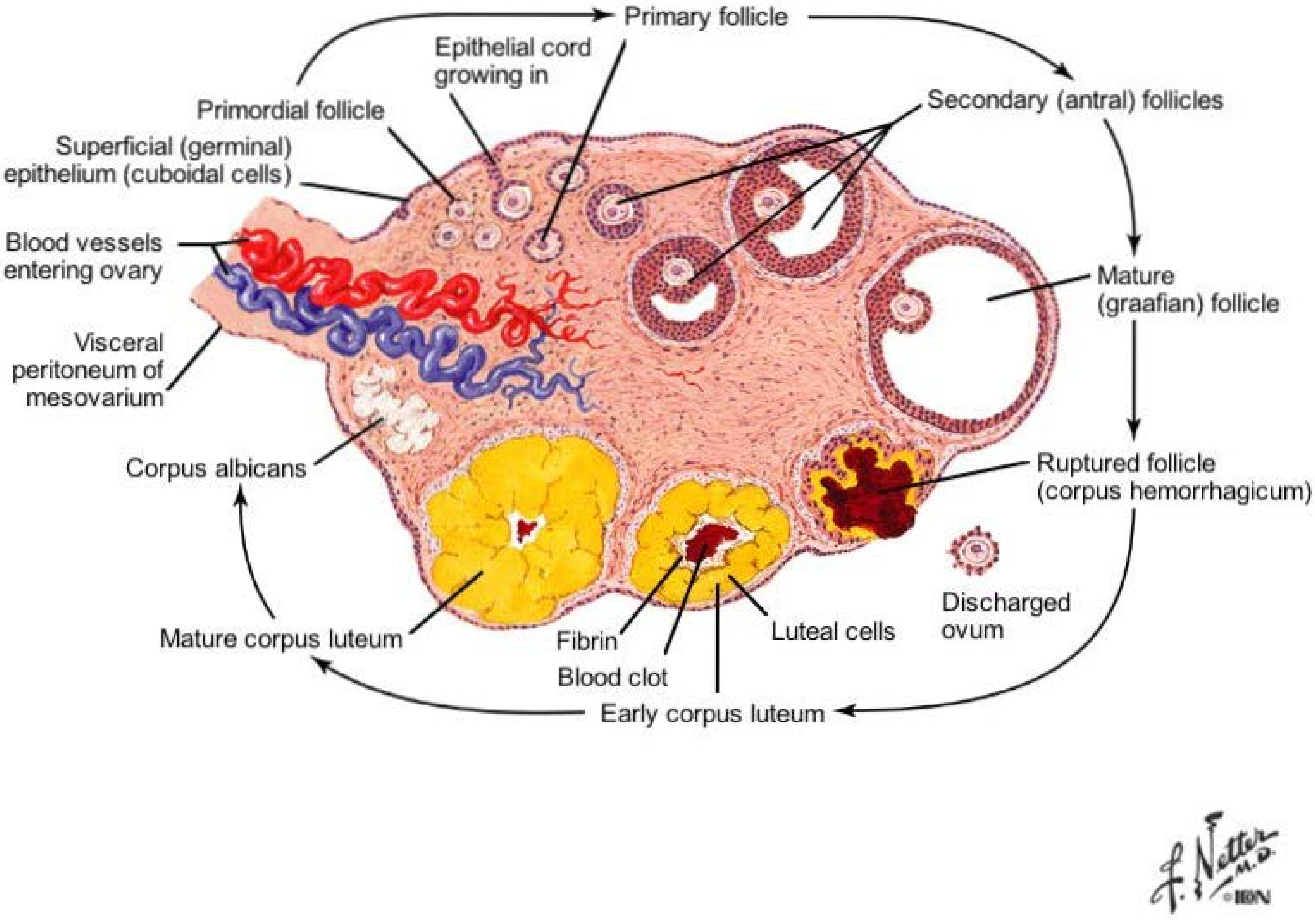


Ovary, Ova, and Follicle Development

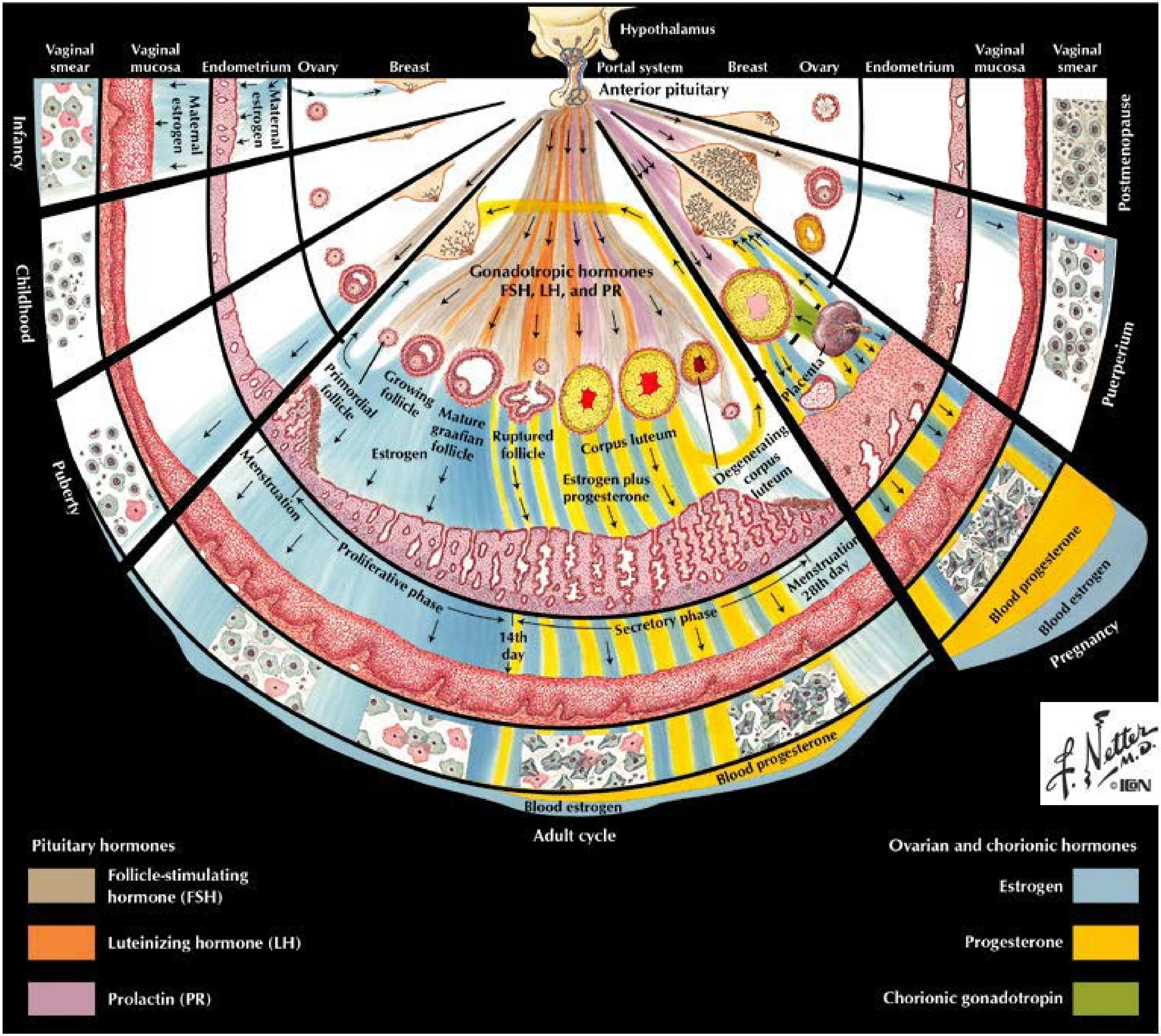


Ovary, Ova, and Follicle Development

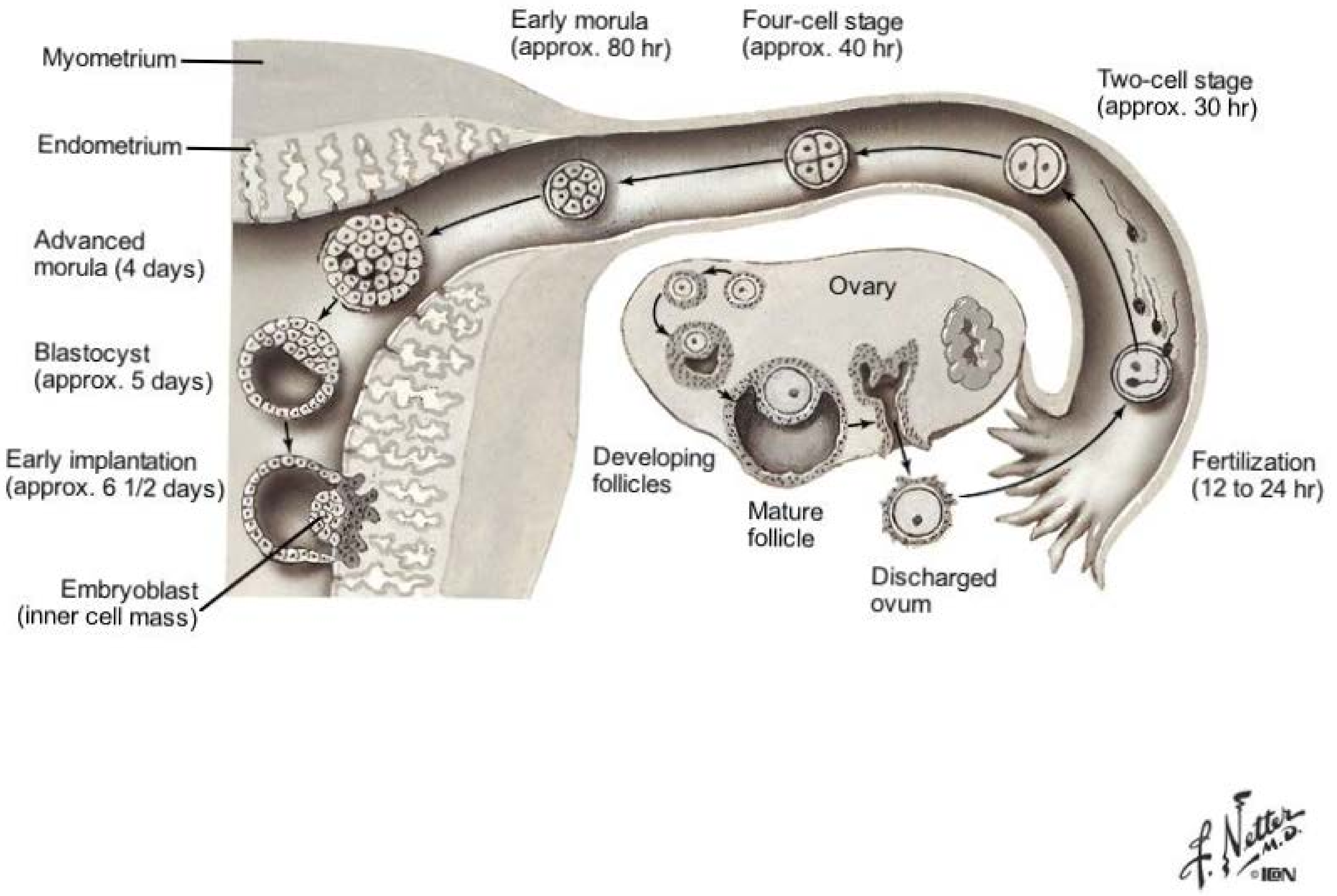
Stages of ovum and follicle



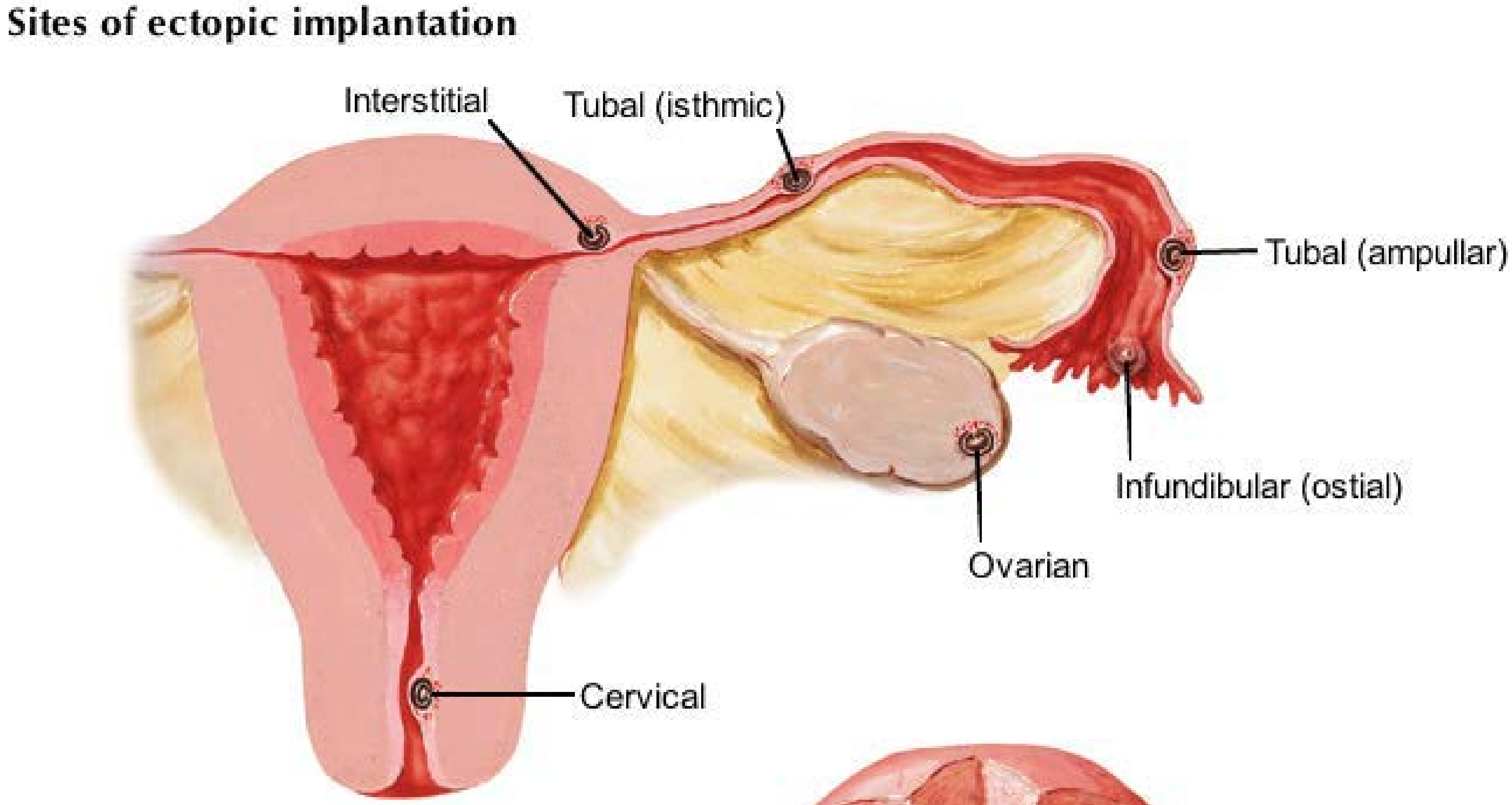
The Menstrual Cylce and Pregnancy
Regulation of follicle and endometrial development and pregnancy

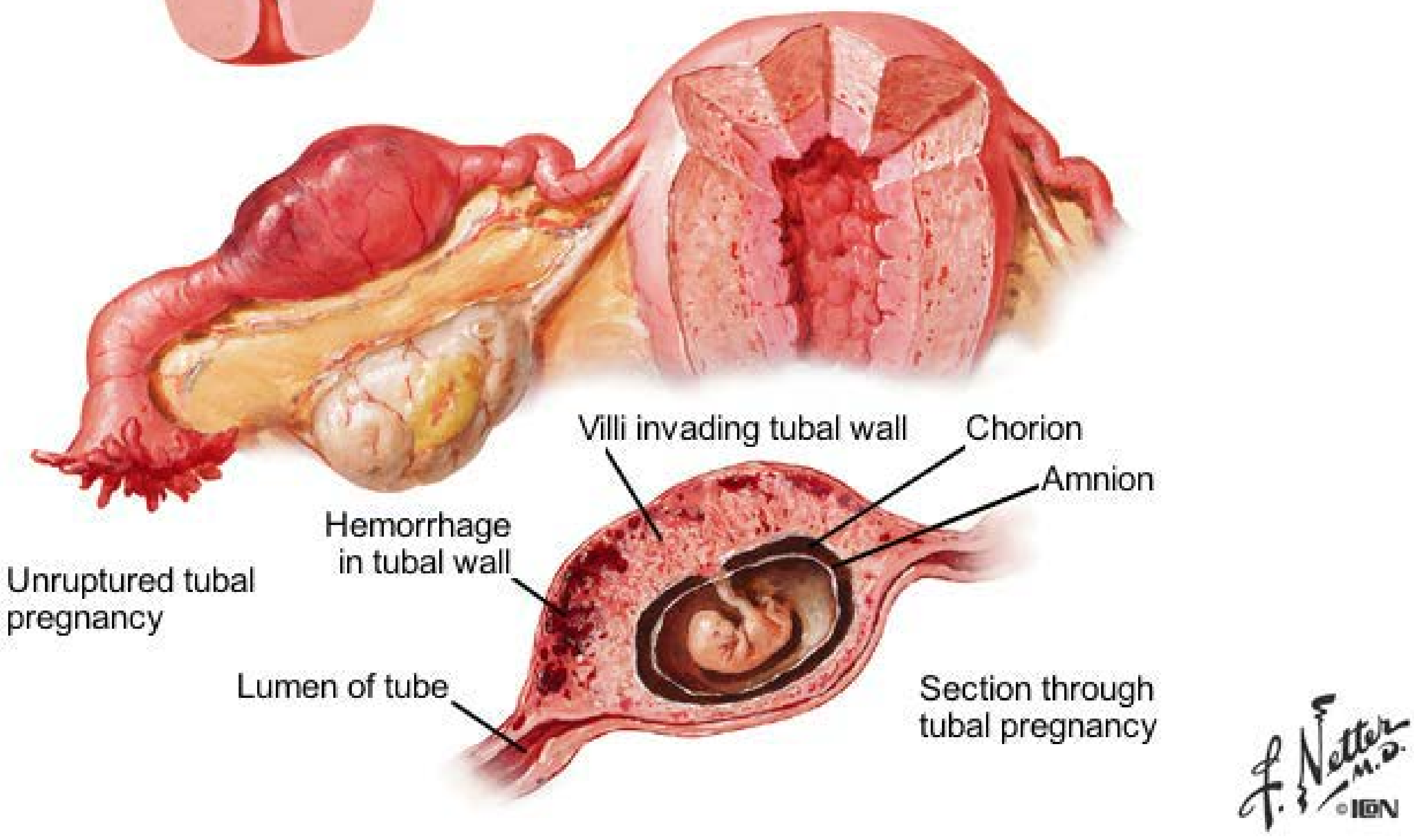


The First Week

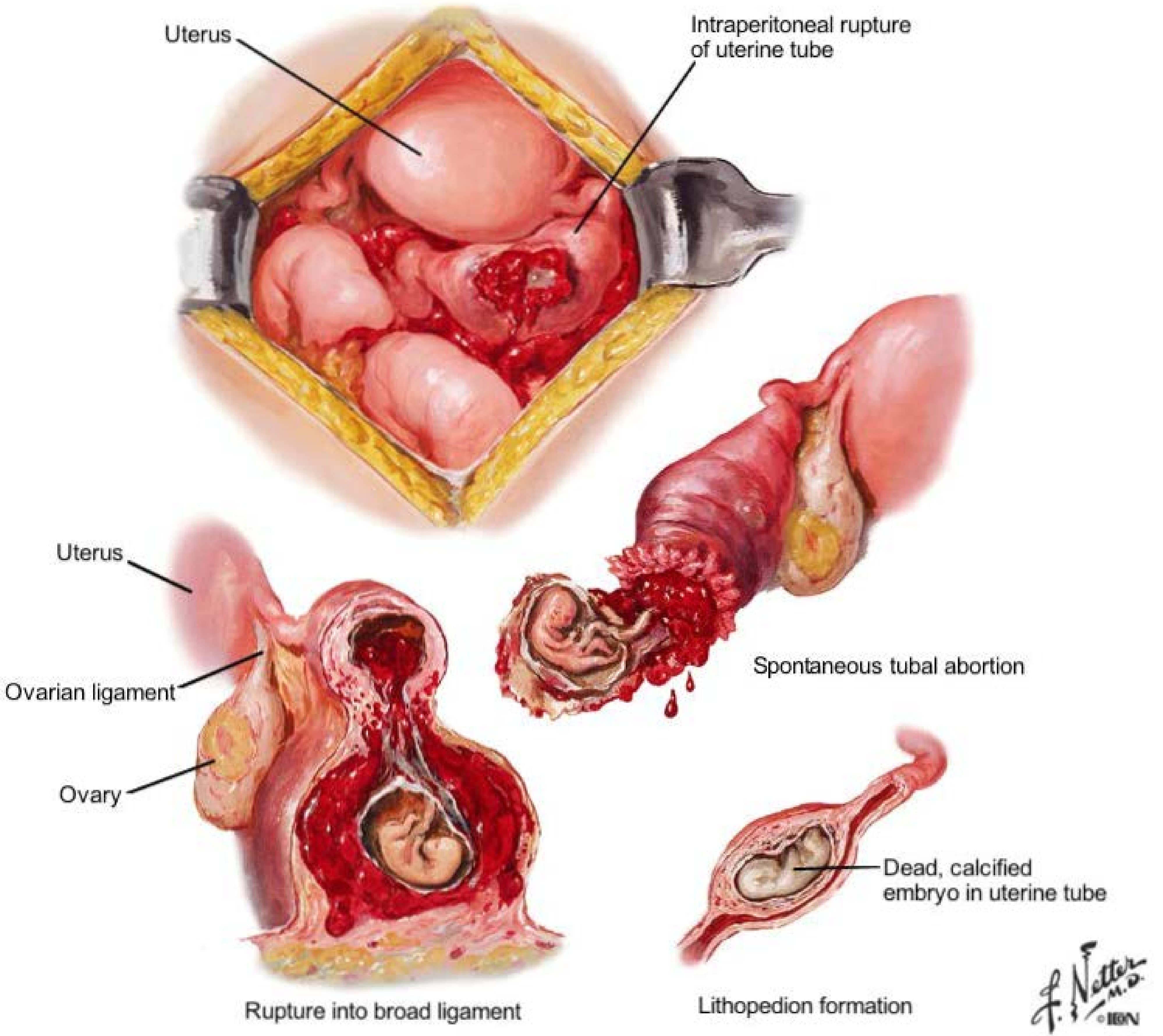


Ectopic Pregnancy





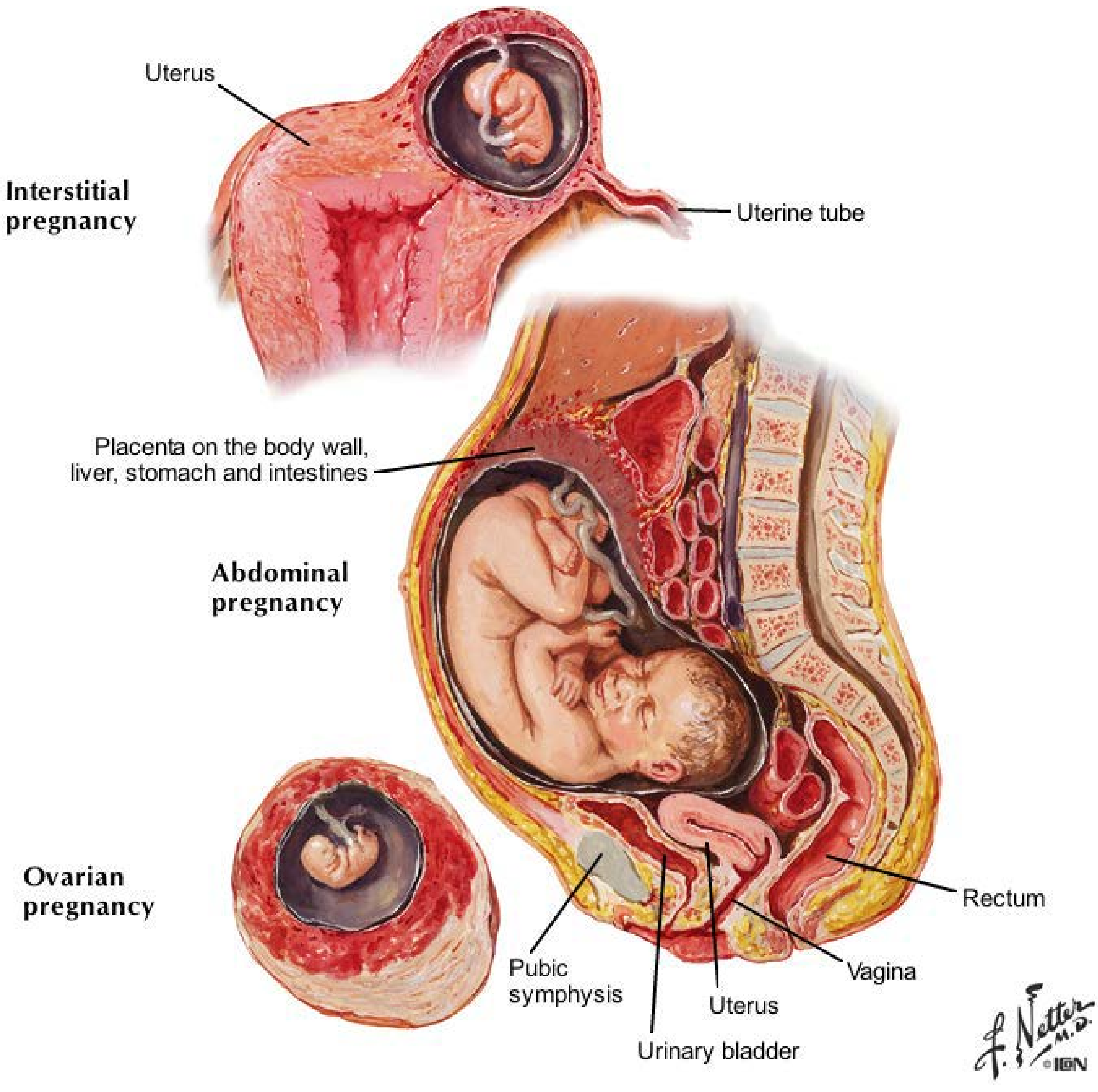
Tubal Prenancy



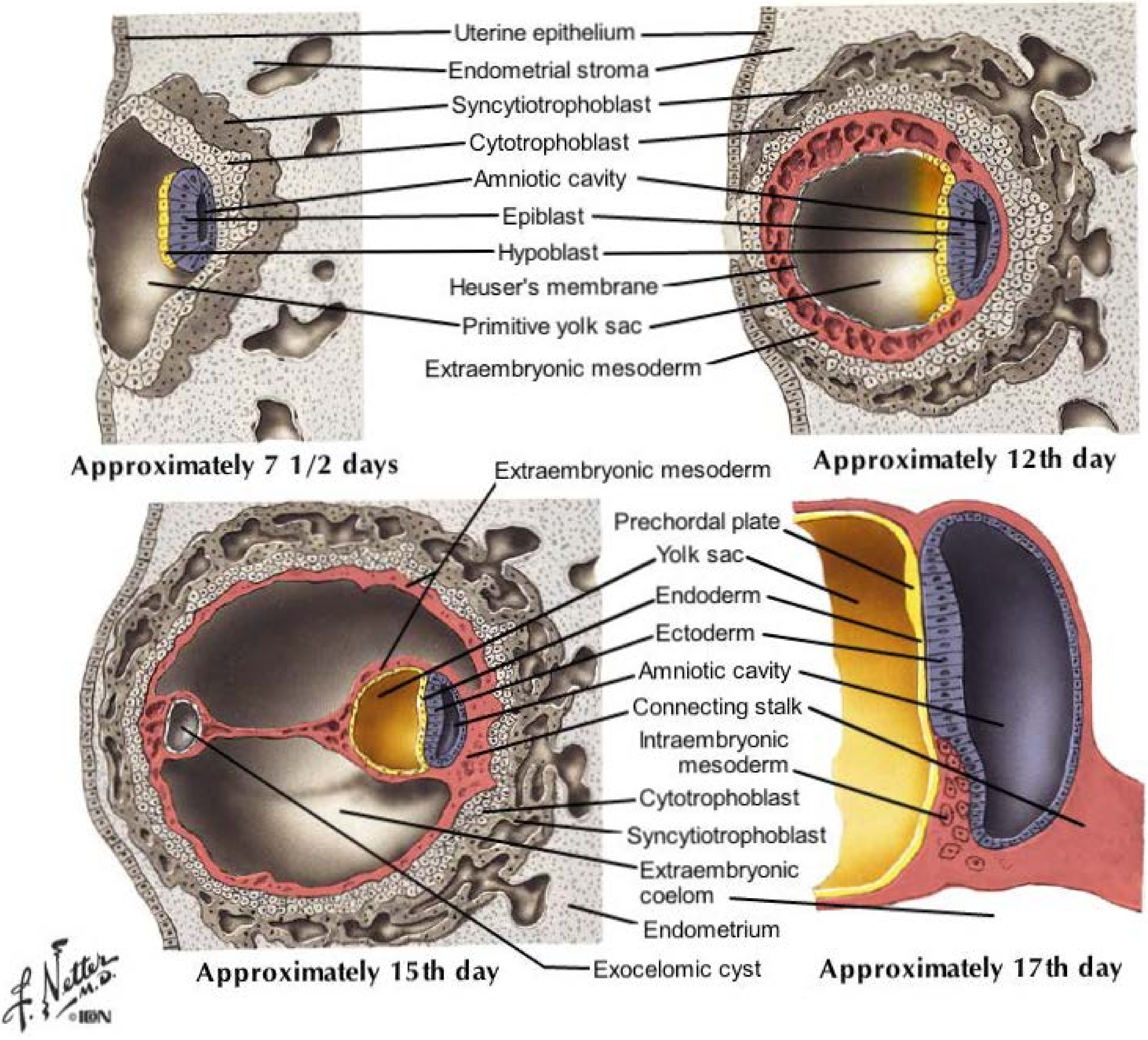
Rupture into broad ligament

Lithopedion formation

Interstitial, Abdominal, and Ovarian Pregnancy

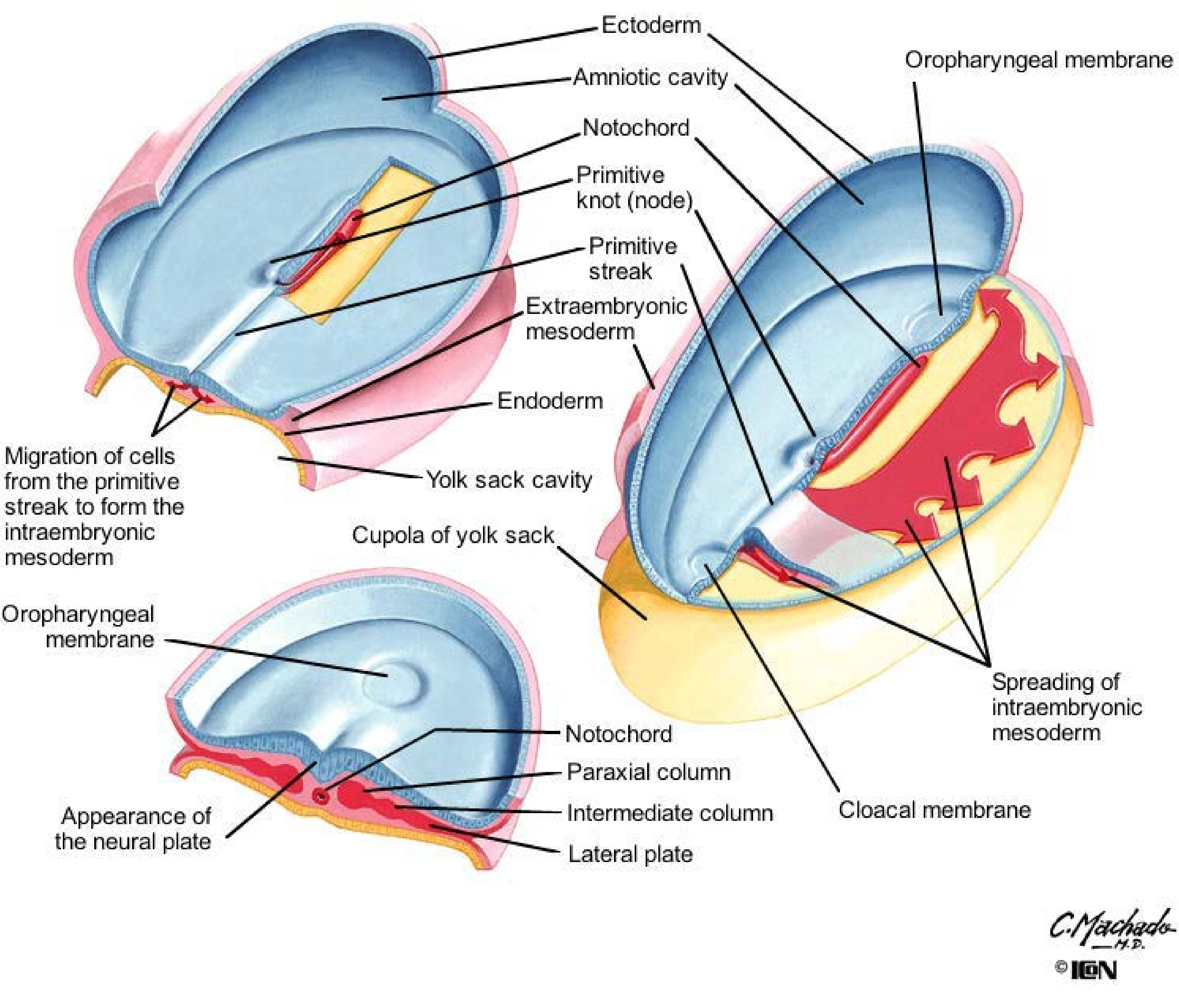


The Second Week

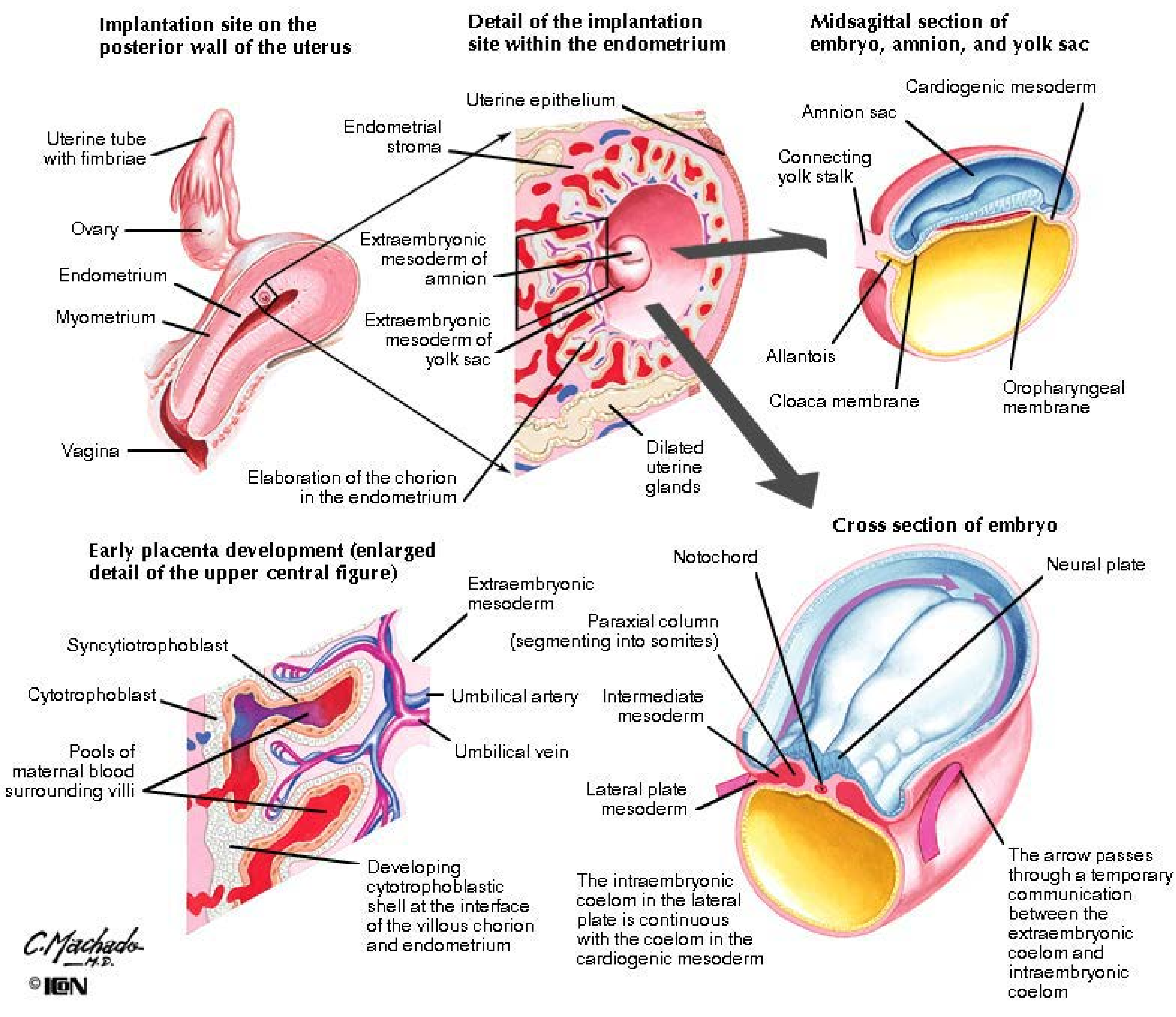


The Third Week

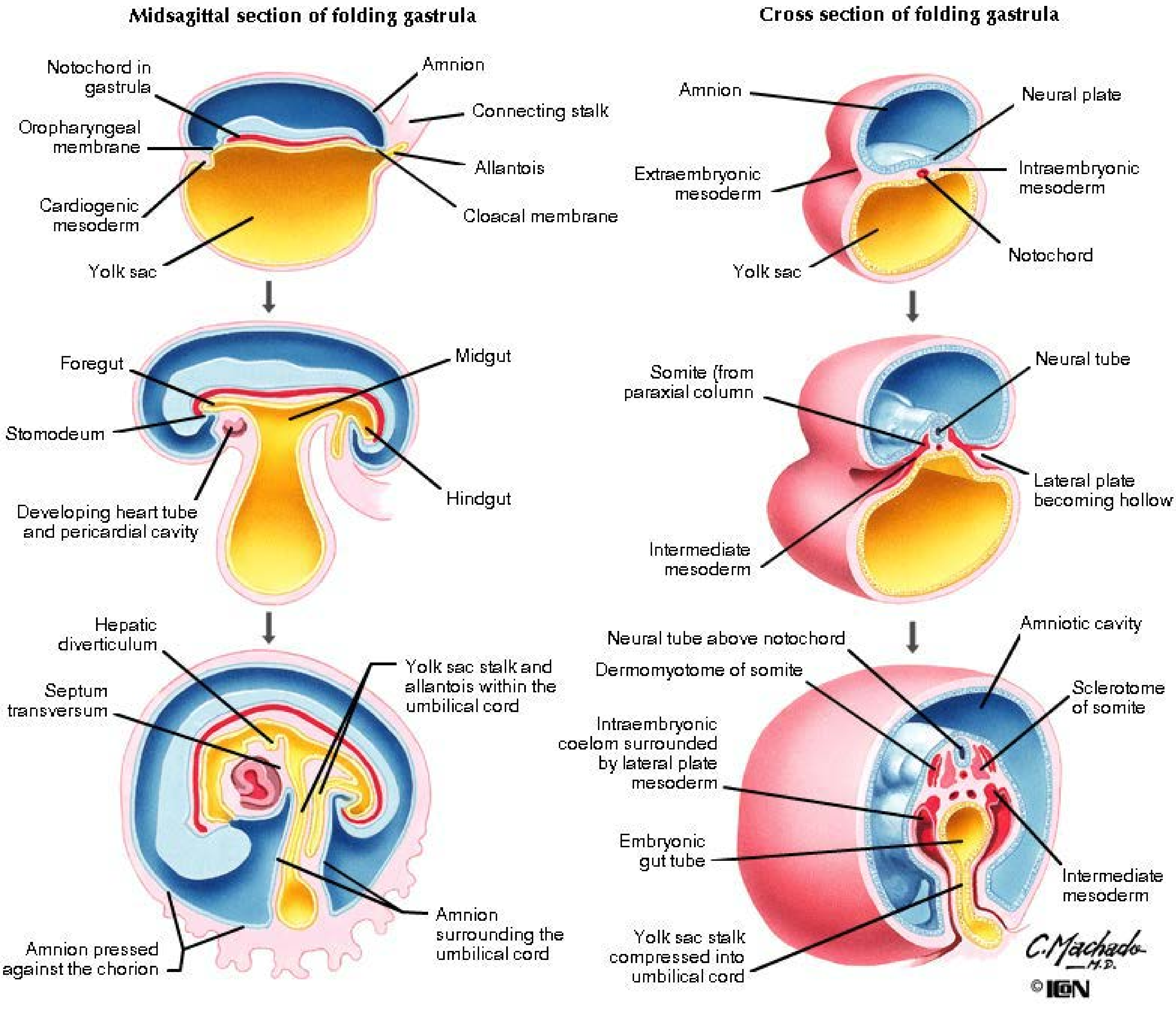
Formation of Intraembryonic Mesoderm from the Primitive Streak and Node (Knot)



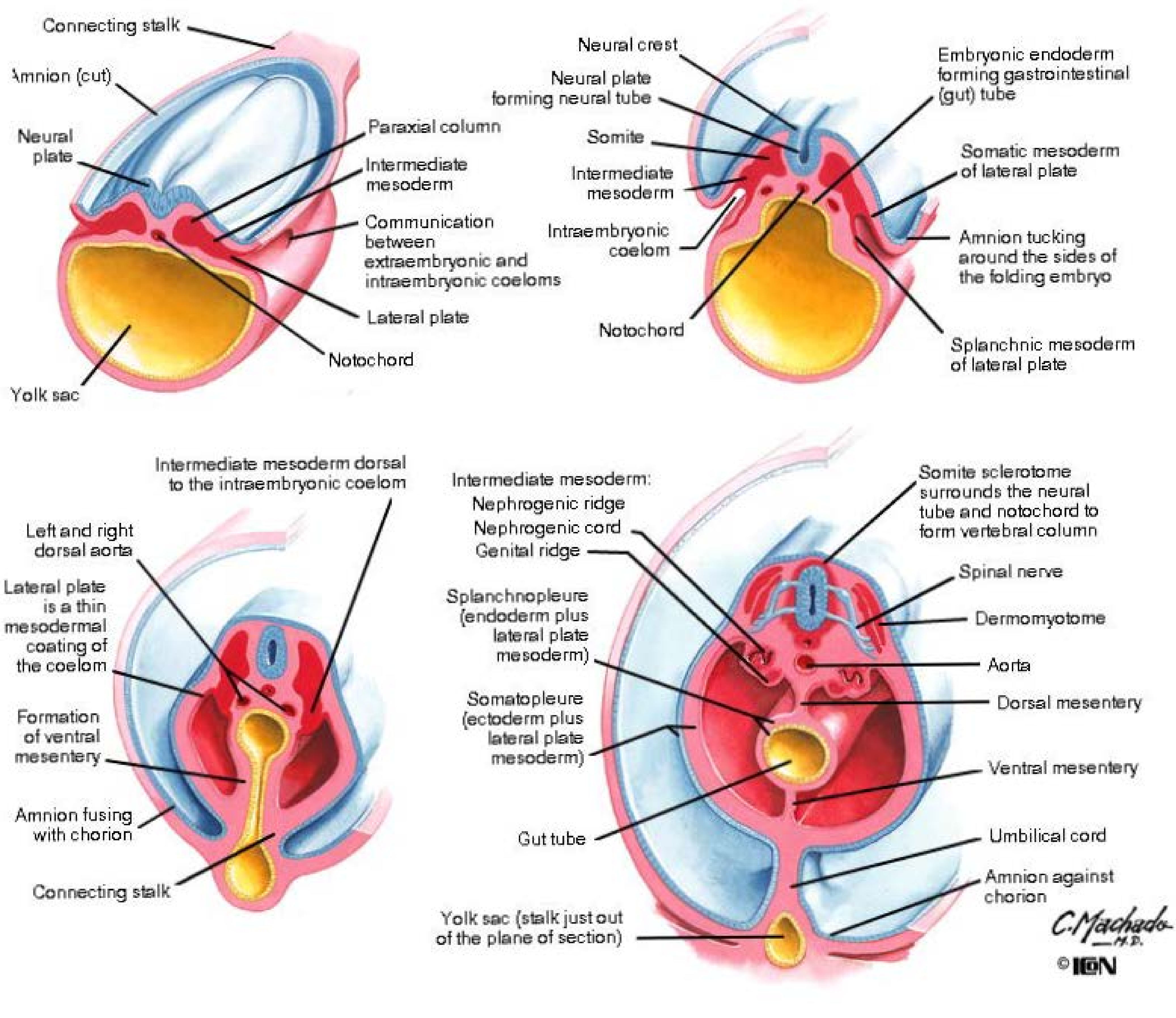
Events Related to Gastrulation



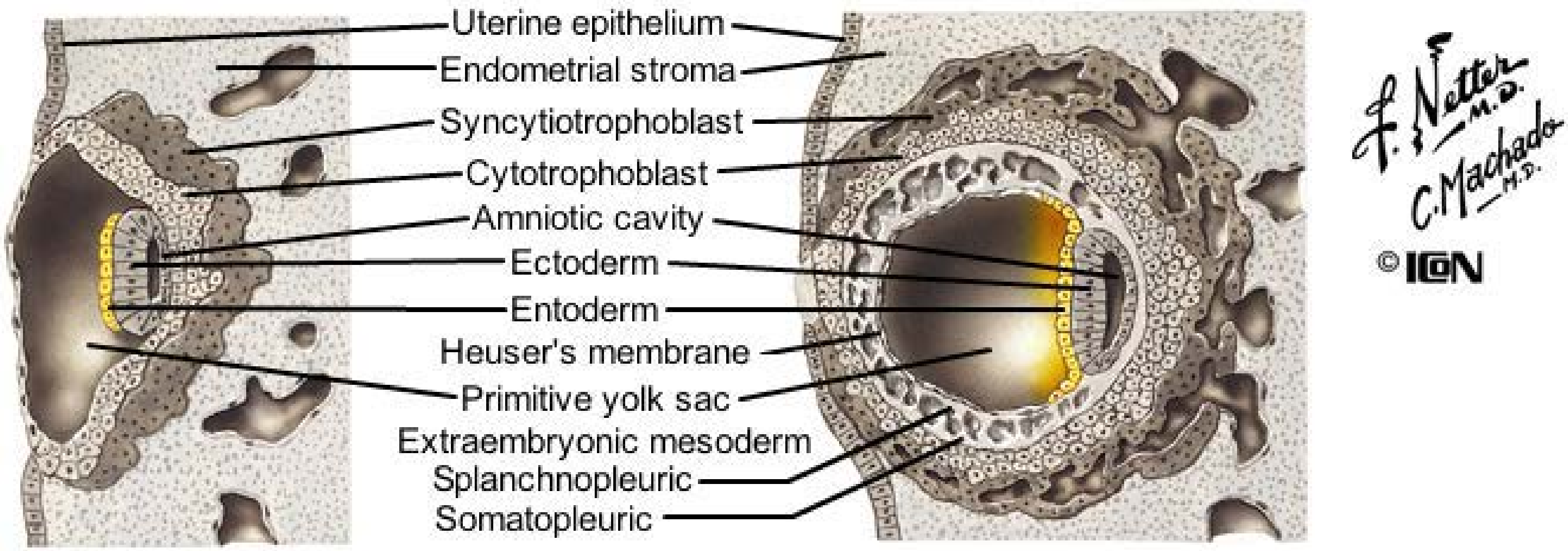
Folding of the Embryo in Week 4



The Vertebrate Body Plan
Vertebrate Body Plan after 4 Weeks

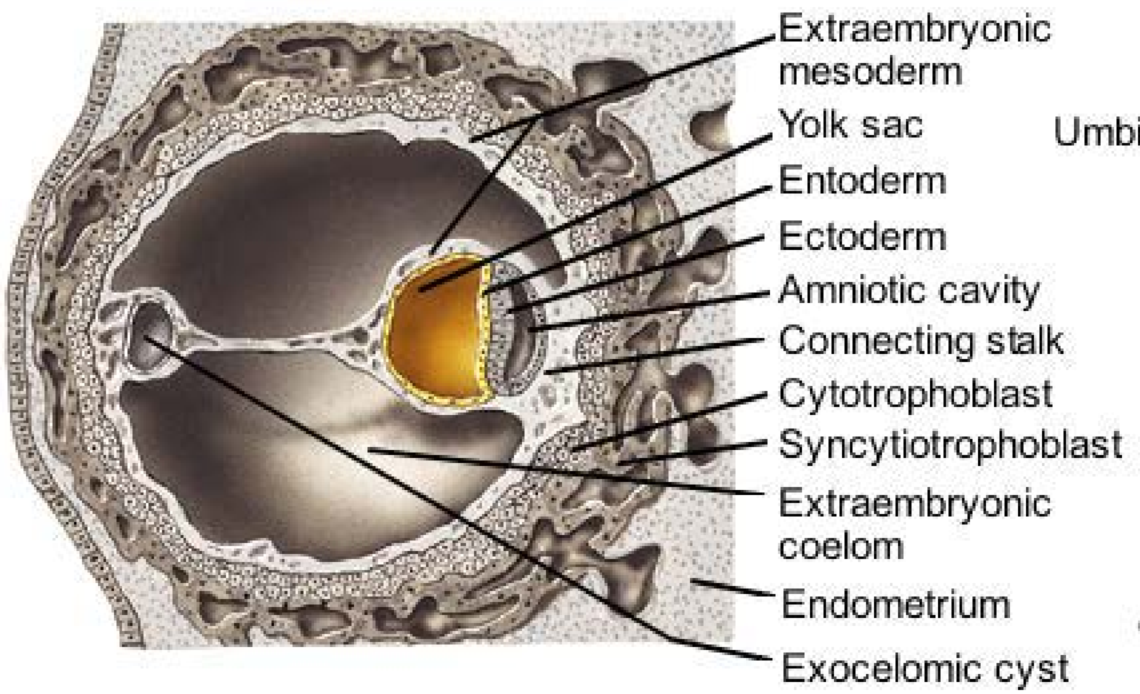


Formation of the Placenta

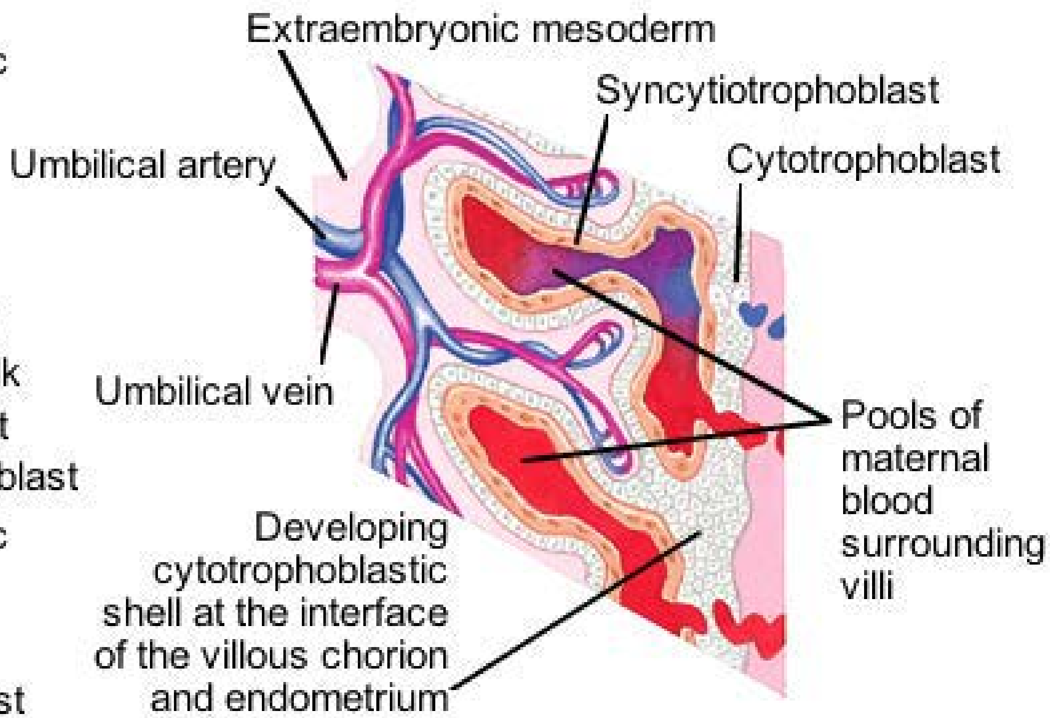


Approximately 7 1/2 days

Approximately 12th day



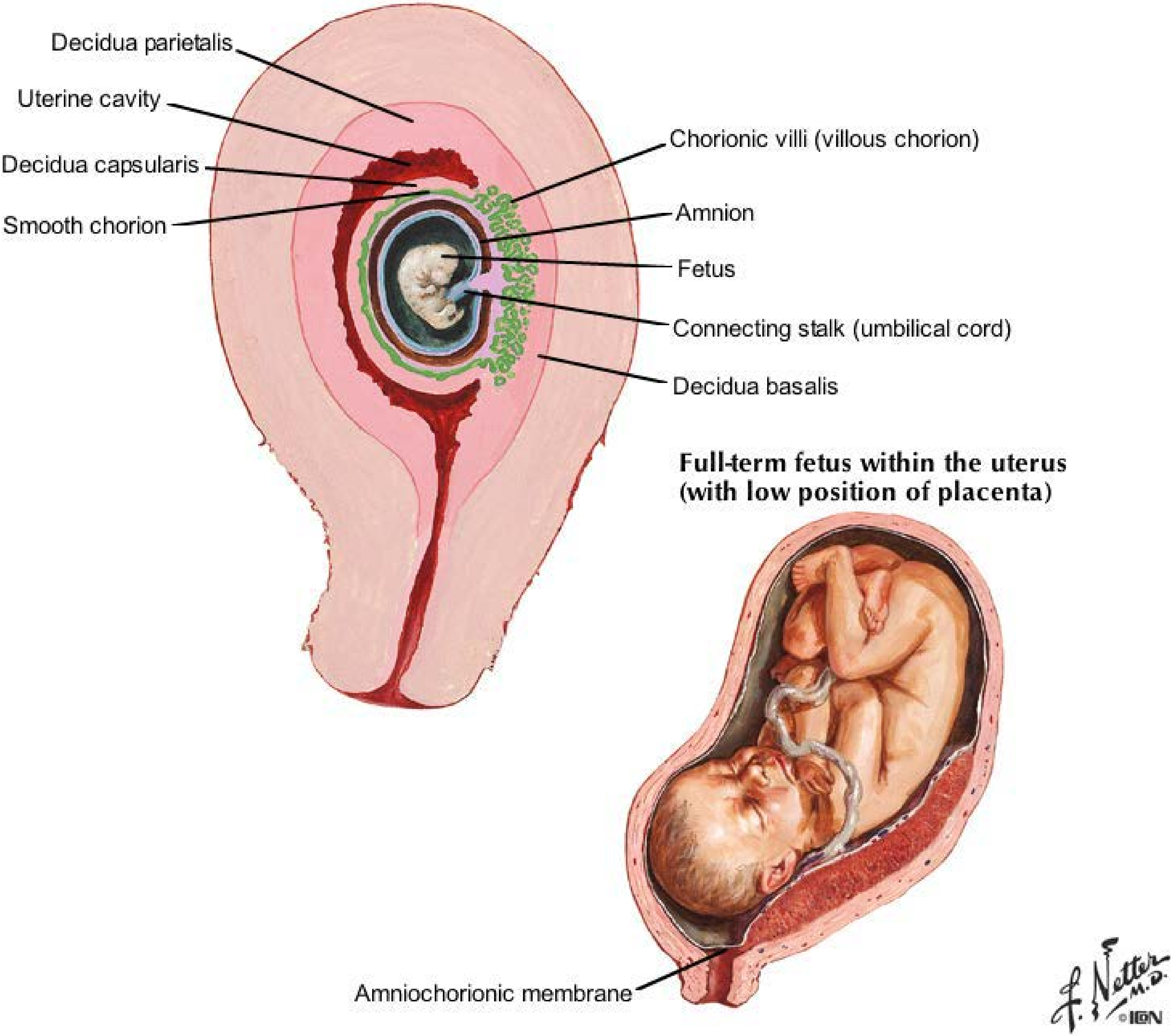
Approximately 15th day



Approximately 25th day and the establishment of placental circulation

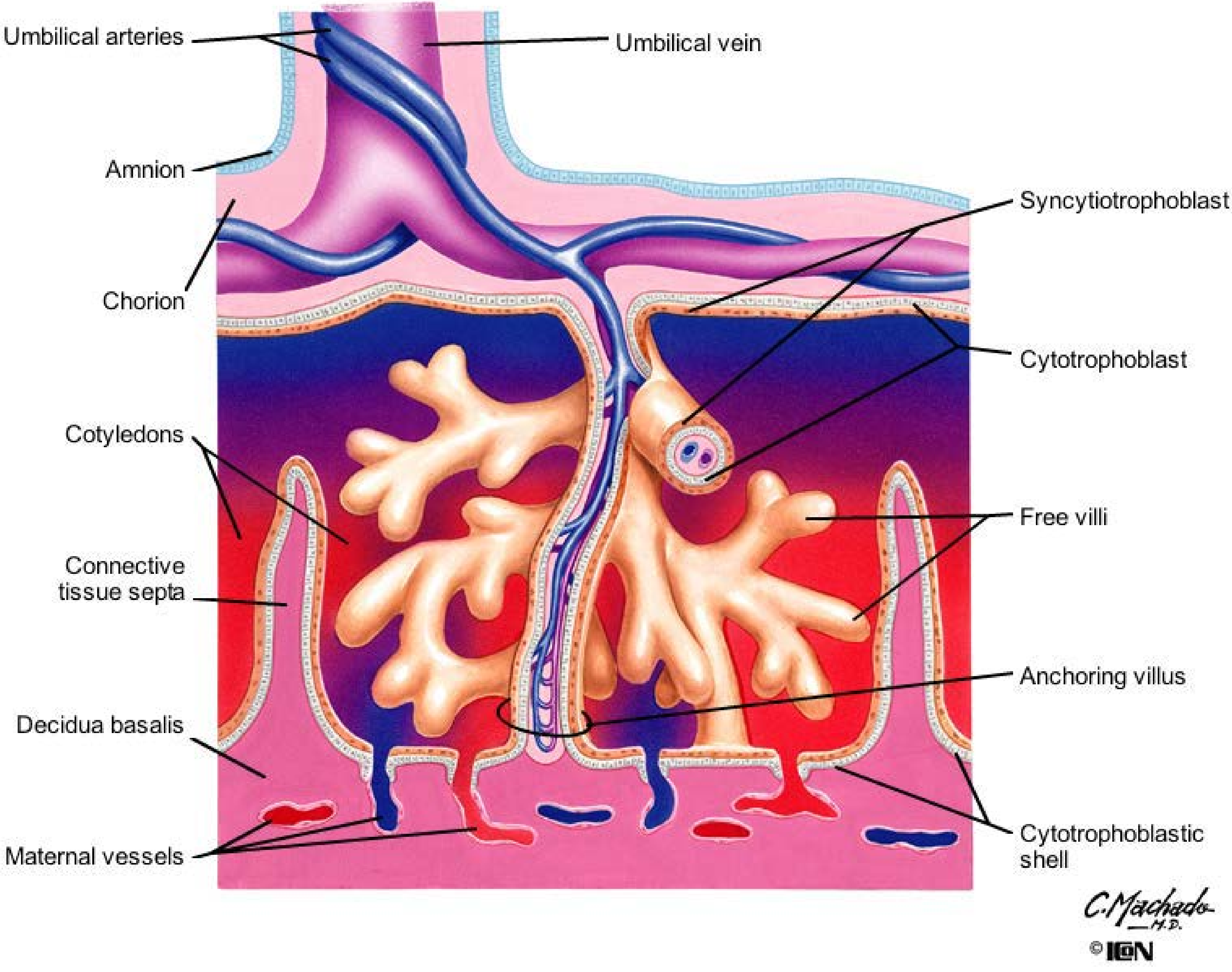
The Endometrium and Fetal Membranes

Early fetal development and membrane formation in relation to the uterus as a whole (schematic)

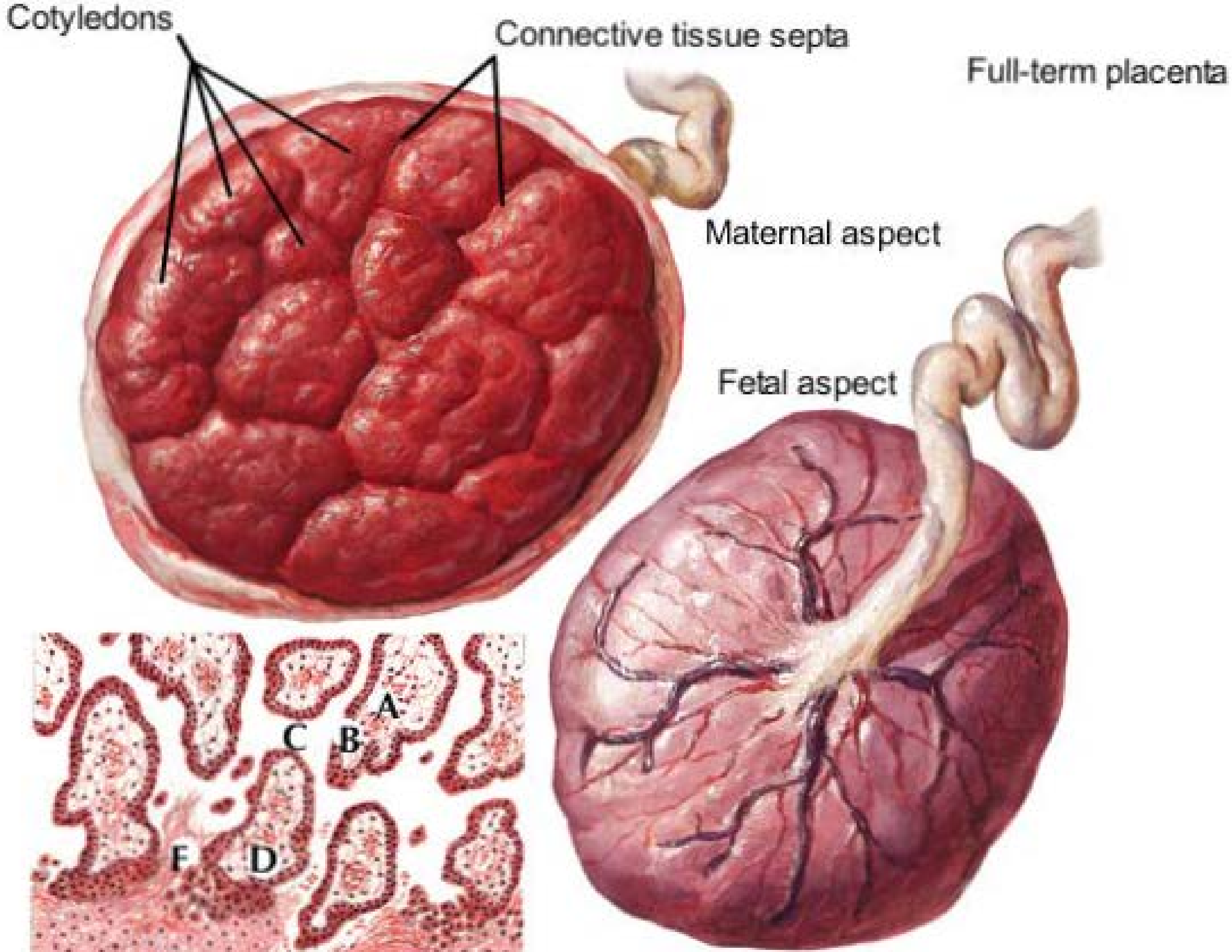


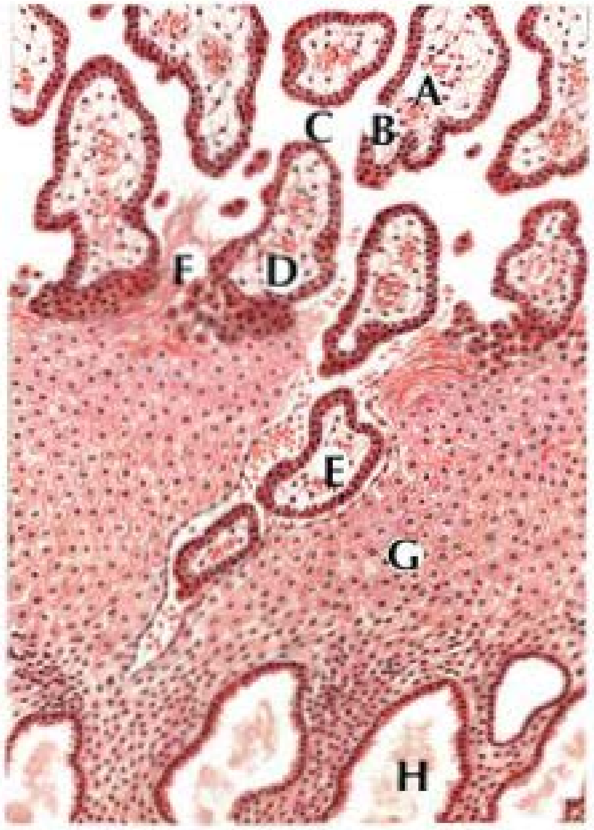
Placental Structure

Development of the placenta: chorionic villi

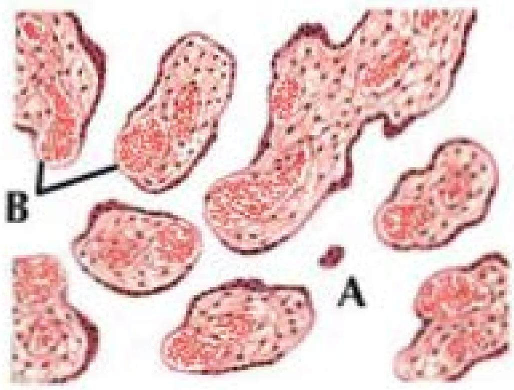


Placental Structure



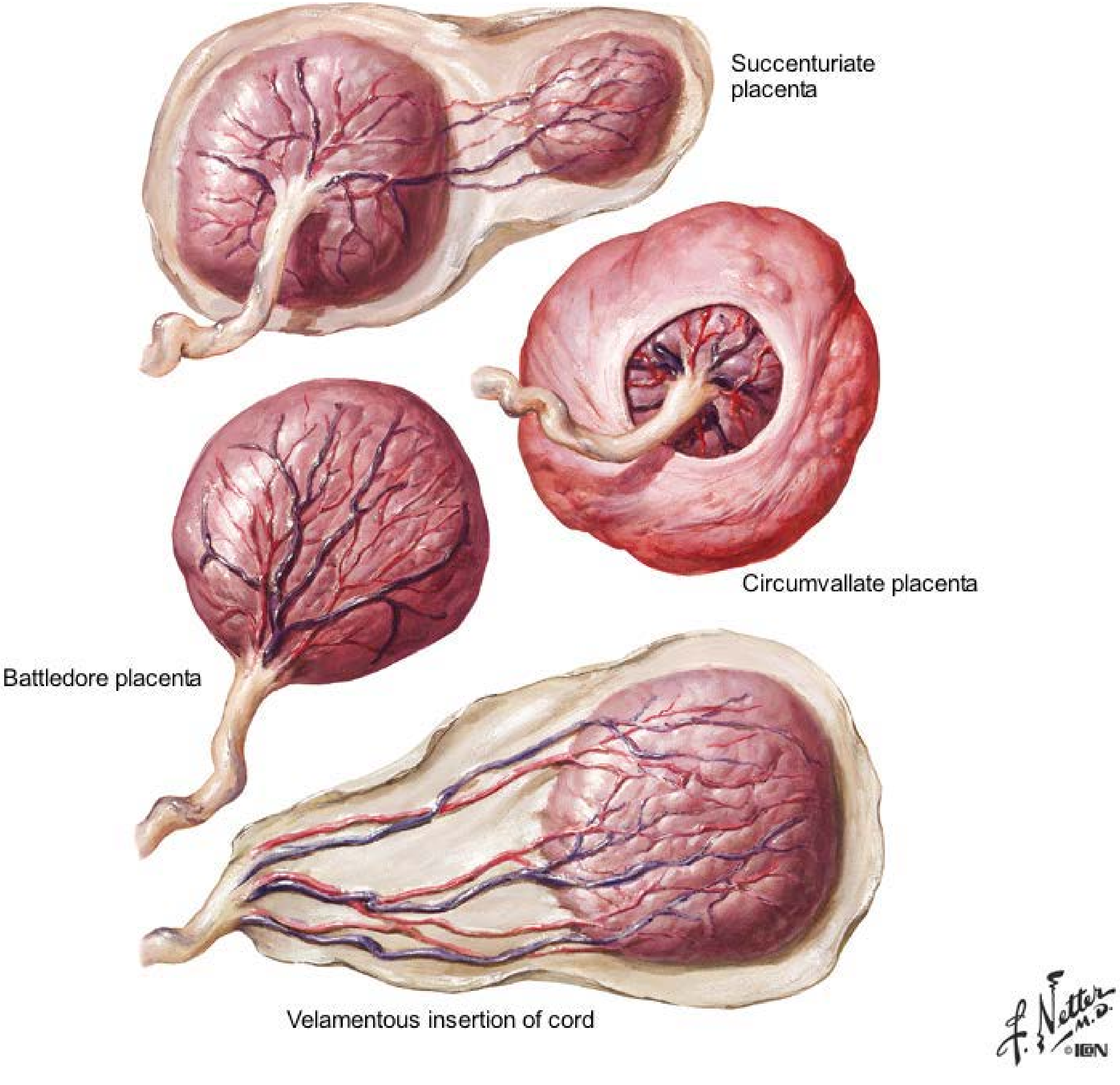


Section through deep portion of placenta-early gestation
(A) Villus, (B) trophoblast, (C) intervillous space, (D) anchoring villus, (E) villus invading blood vessel, (F) fibrinoid degeneration, (G) decidua basalis, (H) gland

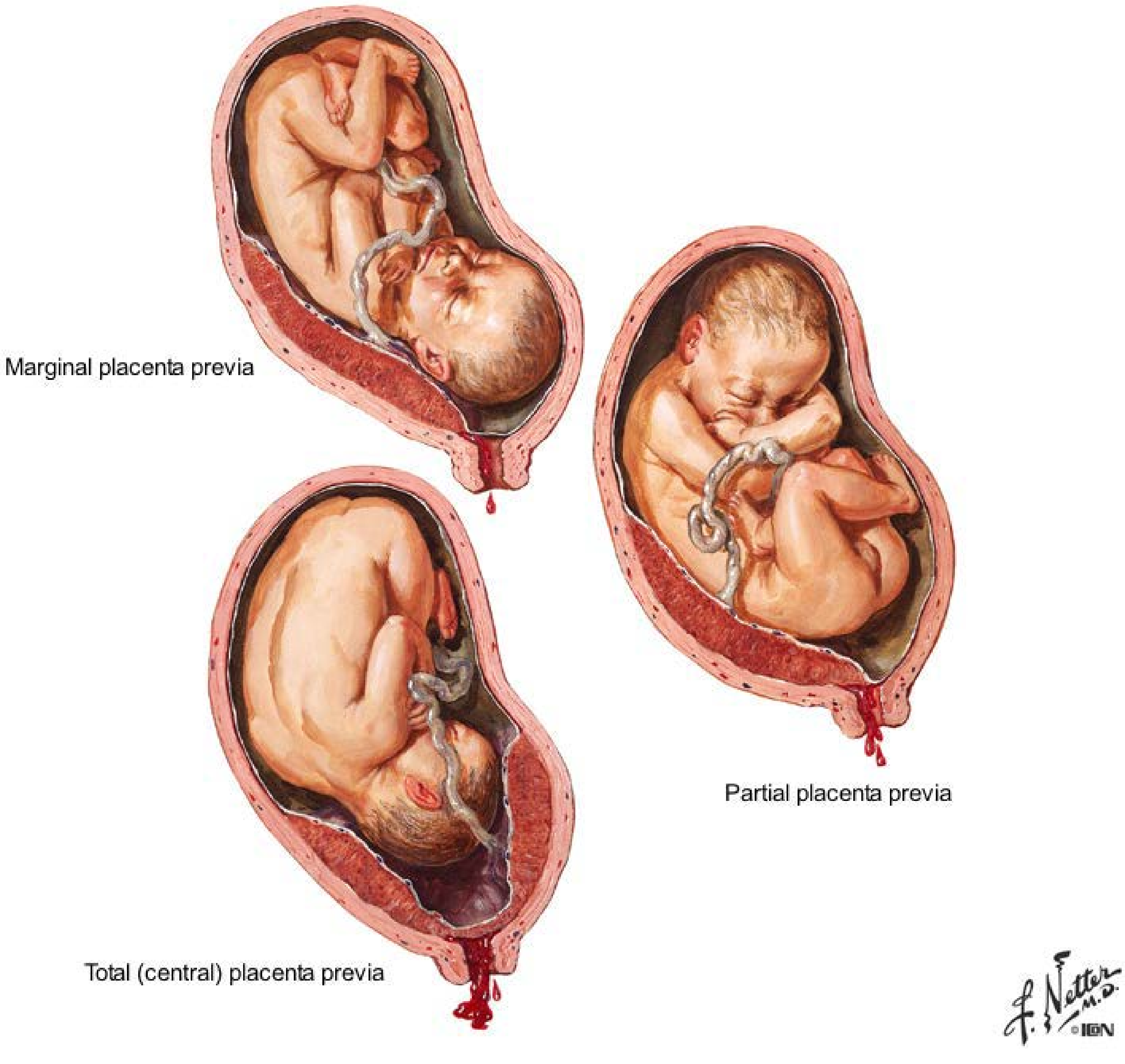


Appearance of placental villi at term
(A) Syncytial cell mass becoming trophoblastic embolus, (B) fetal blood vessel endothelium against a thinned syncytiotrophoblast, where they share a basal lamina. The cytotrophoblast has disappeared

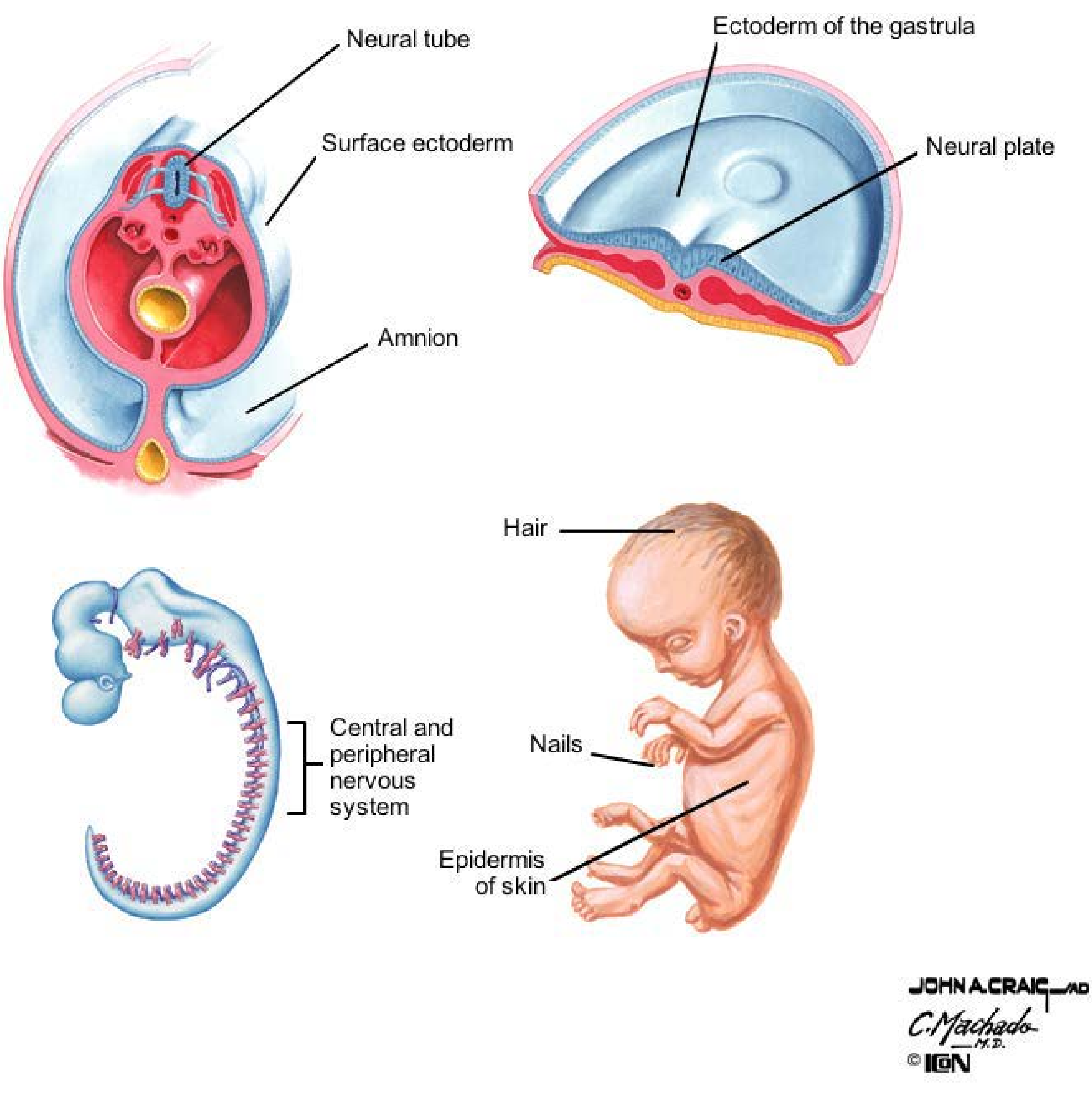
Placental Variations



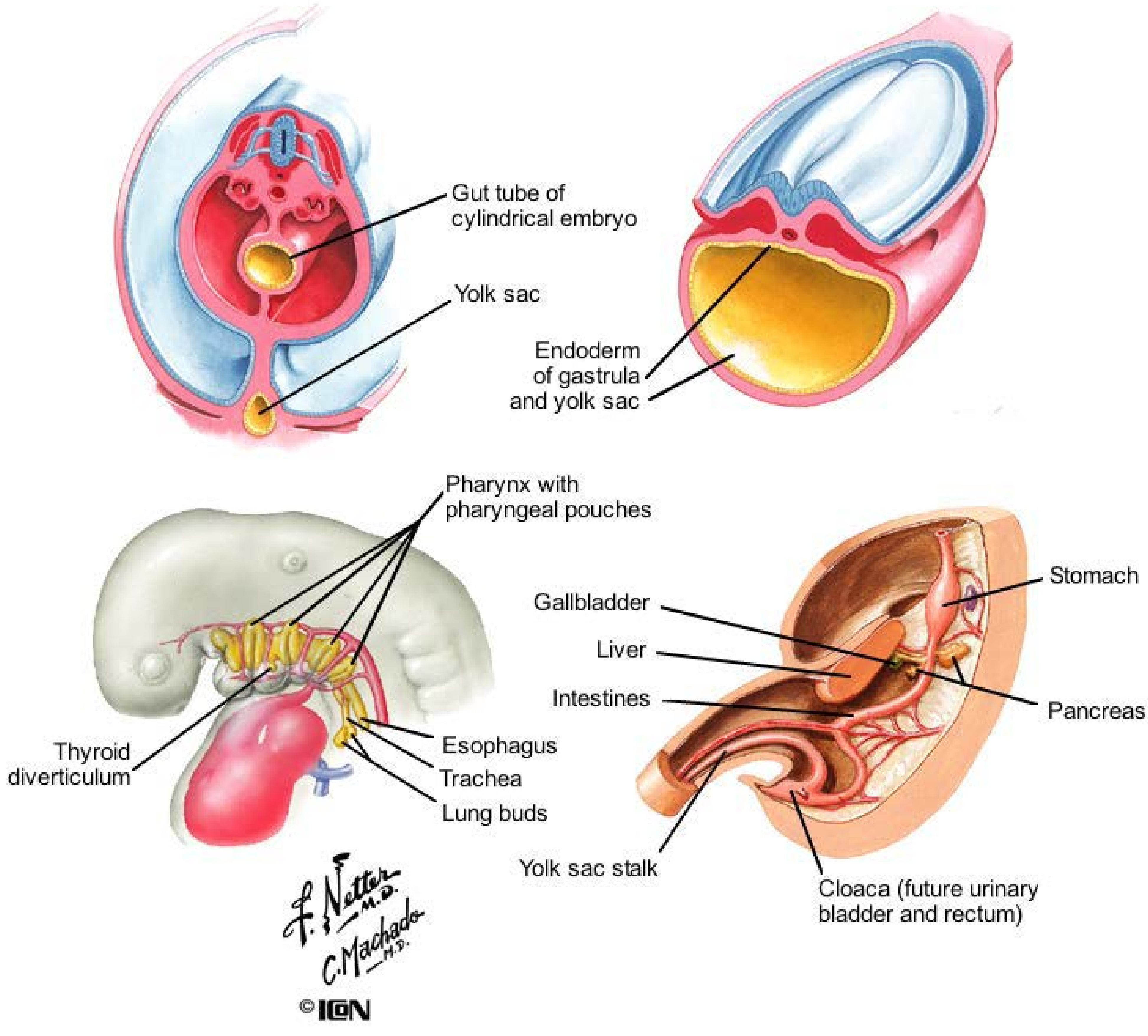
Placenta Previa



Summary of Ectodermal Derivatives



Summary of Endodermal Derivatives



Summary of Mesodermal Derivatives

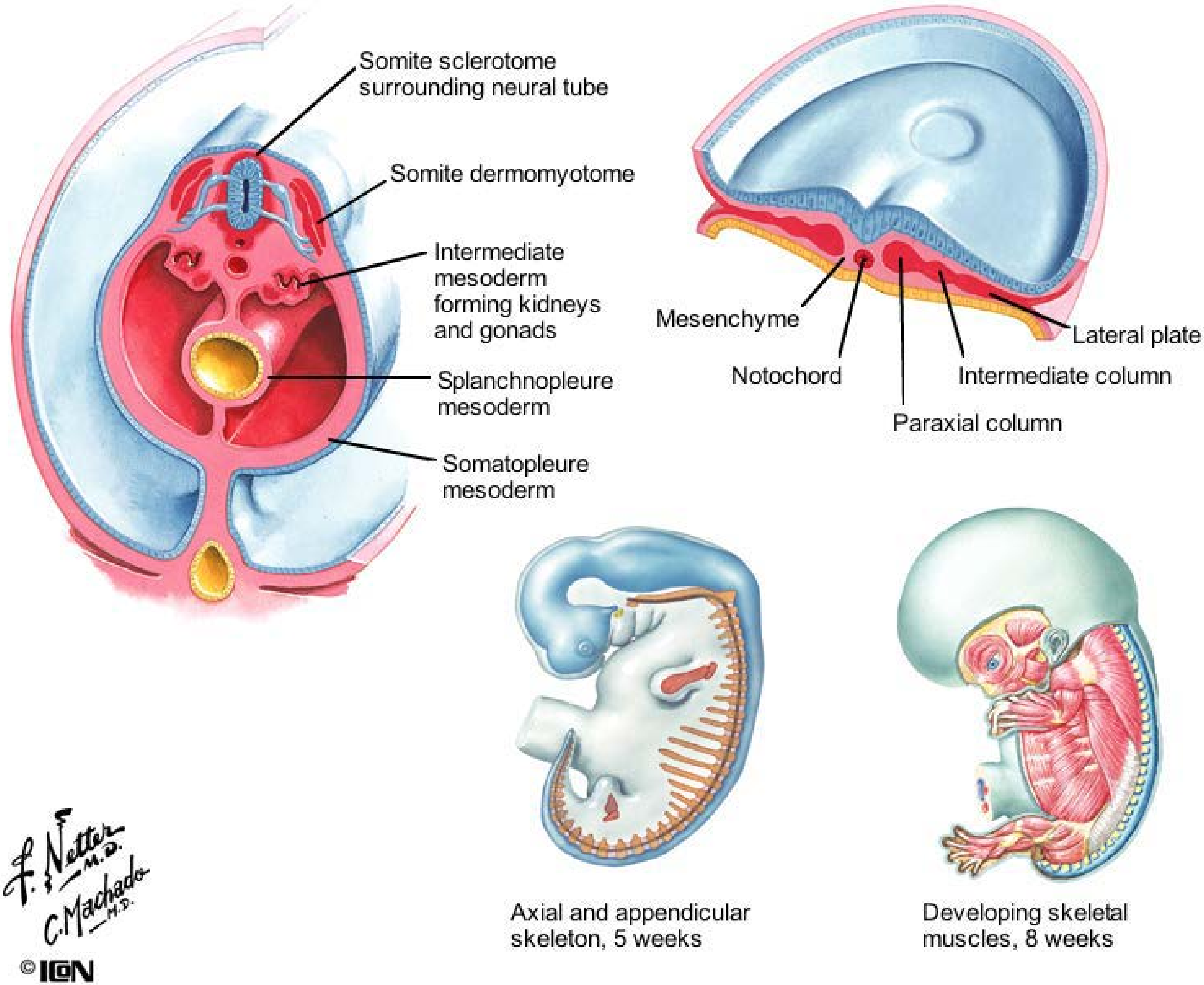


Chart 2.1 Ectodermal Derivatives

Primordia	Derivatives or Fate
Surface ectoderm	Epidermis of the skin
	Sweat, sebaceous, and mammary glands
	Nails and hair
	Tooth enamel
	Lacrimal glands
	Conjunctiva
	External auditory meatus
(Stomodeum and nasal placodes)	Oral and nasal epithelium
	Anterior pituitary
(Otic placodes)	Inner ear
(Lens placodes)	Lens of eye
Neural tube	Central nervous system
	Somatomotor neurons
	Branchiomotor neurons
	Presynaptic autonomic neurons
	Retina/optic nerves
	Posterior pituitary
Neural crest	Peripheral sensory neurons
	Postsynaptic autonomic neurons
	All ganglia
	Adrenal medulla cells
	Melanocytes
	Bone, muscle, and connective tissue in the head and neck
Amnion	Protective bag (with chorion) around fetus

Chart 2.2 Endodermal Derivatives

CHART 2.2 ENDODERMAL DERIVATIVES

Primordia	Epithelial Derivatives or Fate
Gut tube endoderm	GI tract (enterocytes) Mucosal glands of GI tract Parenchyma of GI organs (liver, pancreas) Airway lining (larynx, trachea, bronchial tree) Thyroid gland Tonsils
Cloaca (part of hindgut)	Rectum and anal canal Bladder, urethra, and related glands Vestibule Lower vagina
Pharyngeal pouches (part of foregut)	Auditory tube and middle ear epithelium Palatine tonsil crypts Thymus gland Parathyroid glands C cells of the thyroid gland
Yolk sac	Embryonic blood cell production (mesoderm) Pressed into umbilical cord, then disappears
Allantois (from yolk sac, then cloaca)	Embryonic blood cell production (mesoderm) Vestigial, fibrous urachus Umbilical cord part disappears

GI, Gastrointestinal.

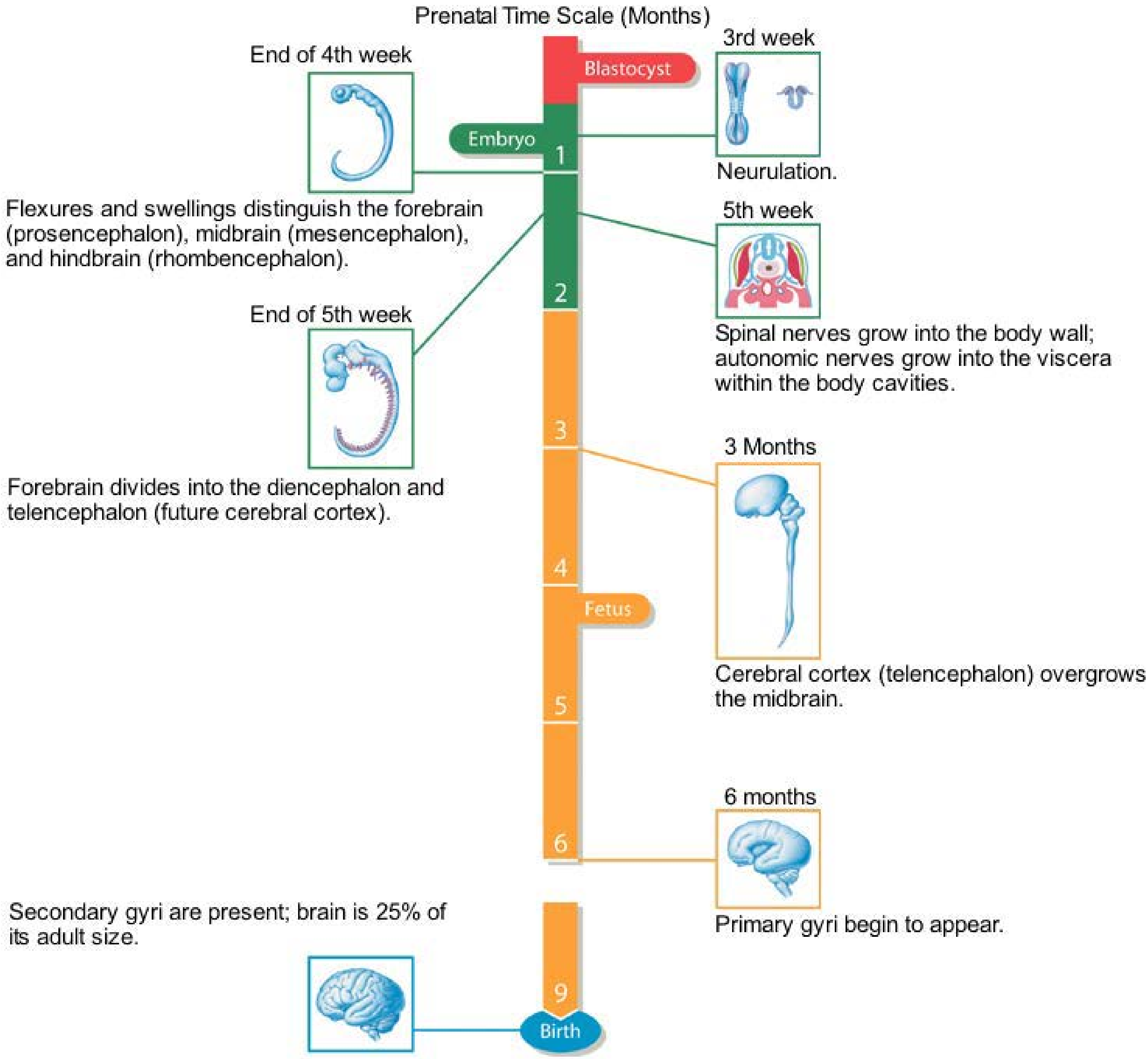
Chart 2.3 Mesodermal Derivatives

CHART 2.3 MESODERMAL DERIVATIVES

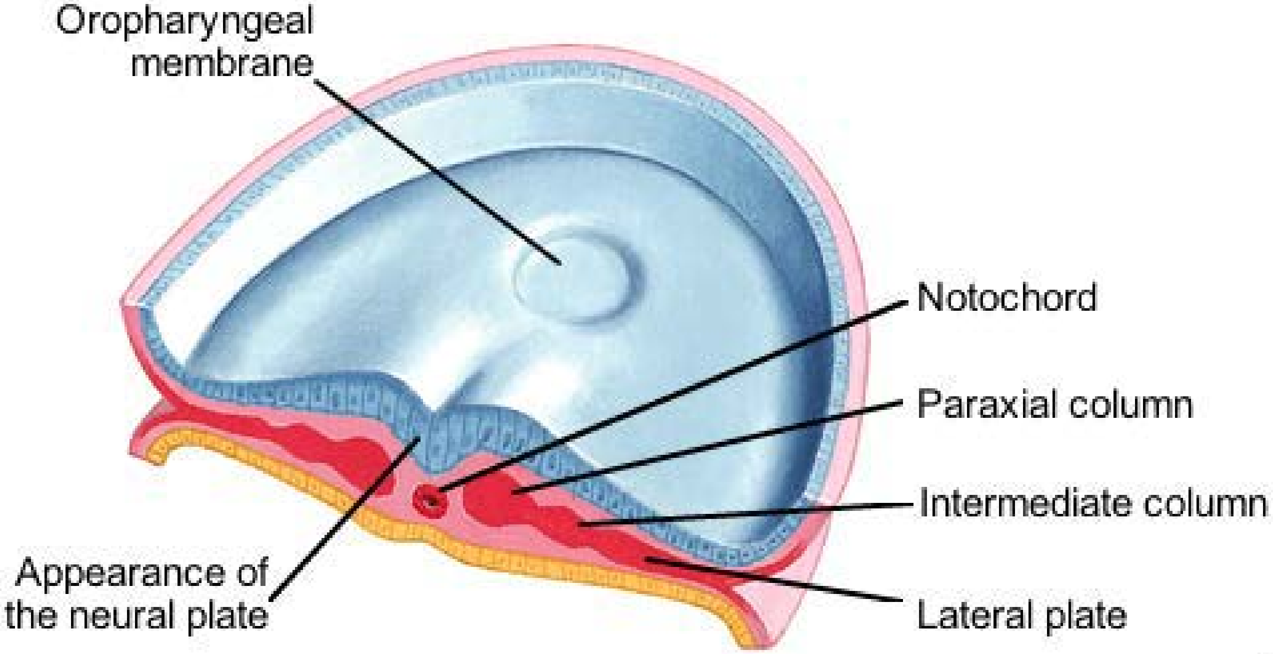
Primordia	Derivatives or Fate
Notochord	Nucleus pulposus of an intervertebral disc Induces neurulation
Paraxial columns (somites)	Skeletal muscle Bone Connective tissue (e.g., dorsal dermis, meninges)
Intermediate mesoderm	Gonads Kidneys and ureters Uterus and uterine tubes Upper vagina Ductus deferens, epididymis, and related tubules Seminal vesicles and ejaculatory ducts
Lateral plate mesoderm	Dermis (ventral) Superficial fascia and related tissues (ventral) Bones and connective tissues of limbs Pleura and peritoneum GI tract connective tissue stroma
Cardiogenic mesoderm	Heart Pericardium

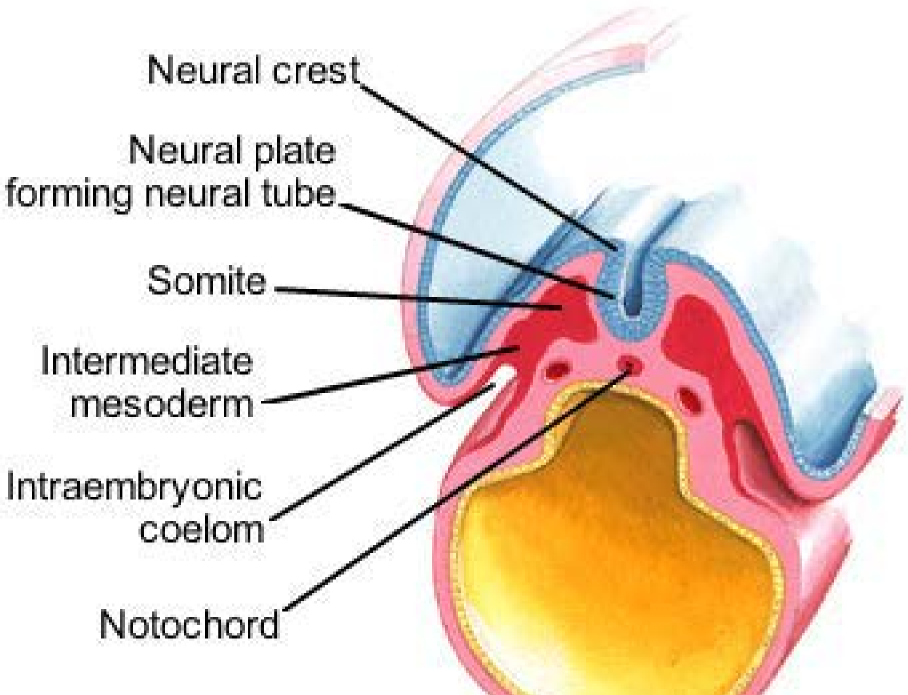
GI, Gastrointestinal.

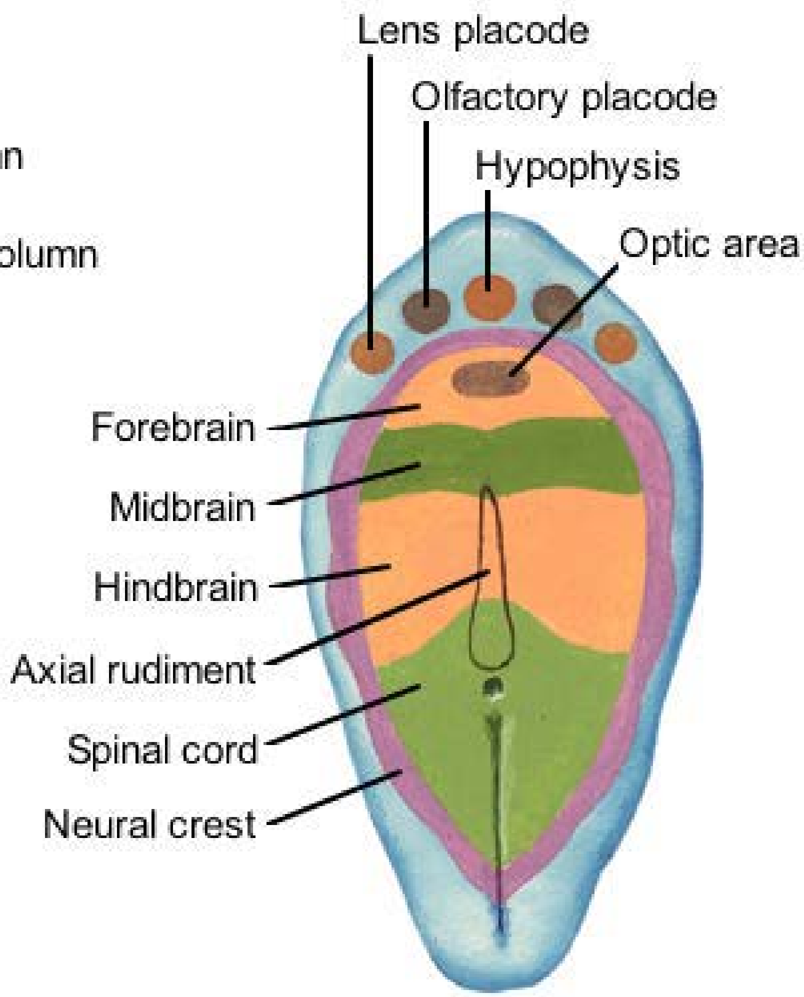
THE NERVOUS SYSTEM
TIMELINE



Formation of the Neural Plate







Developmental fates of local regions of ectoderm of embryonic disc at 18 days

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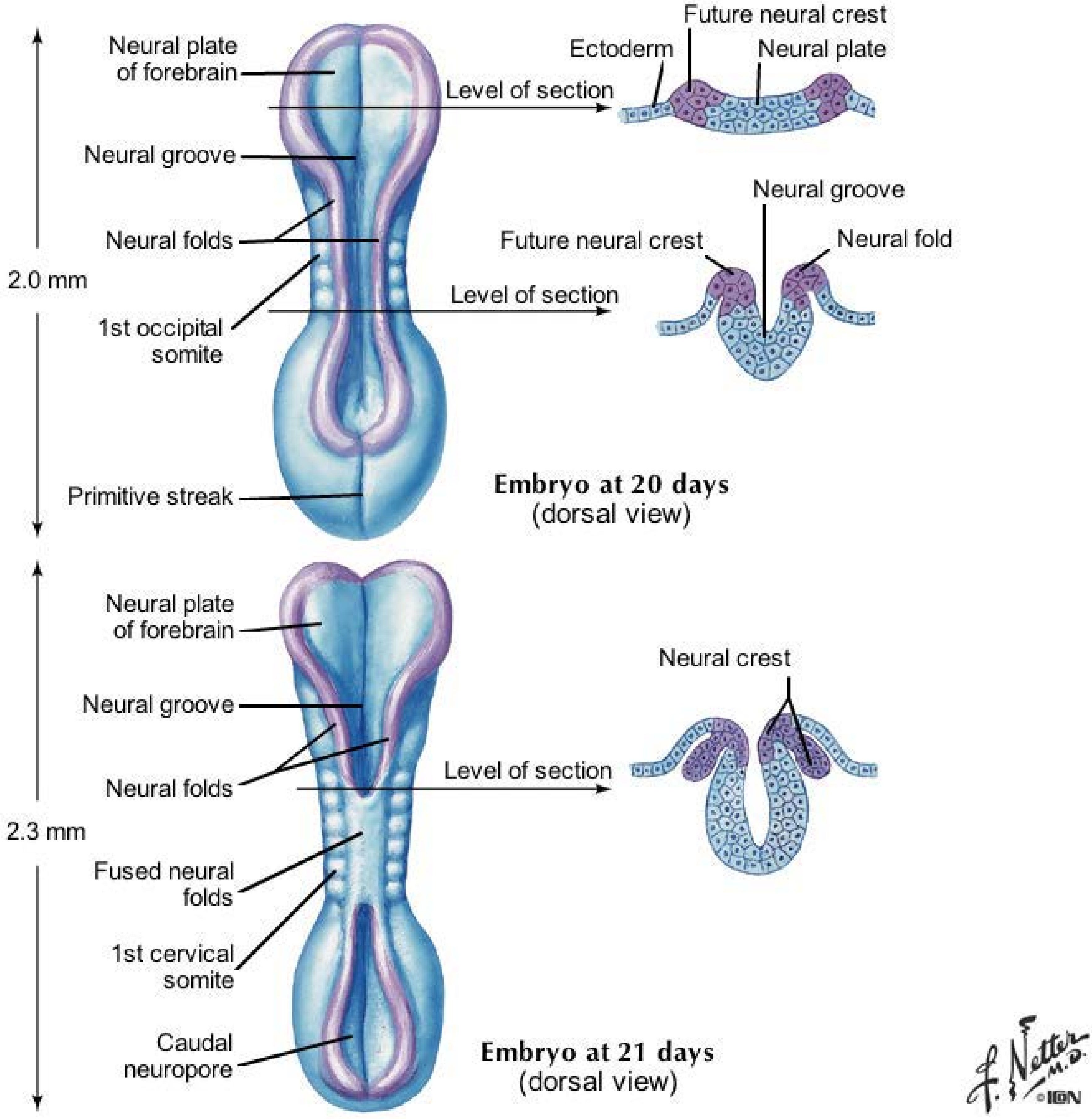
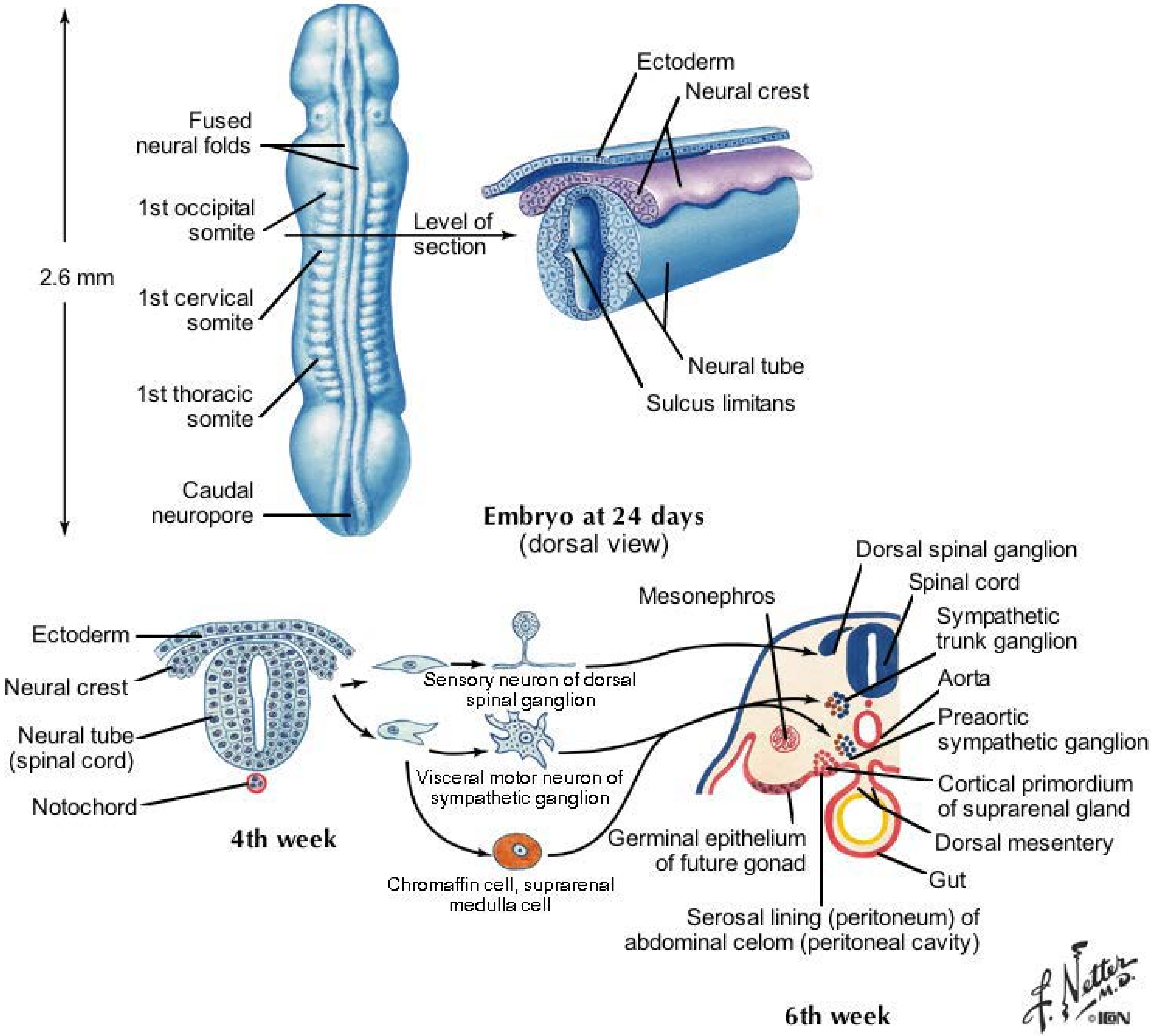
C. Machado M.D.

Neurulation

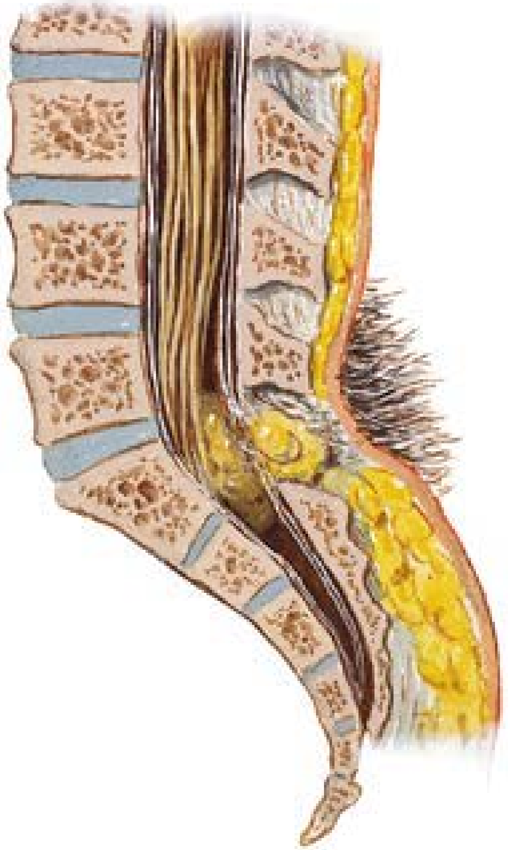


Neural Tube and Neural Crest

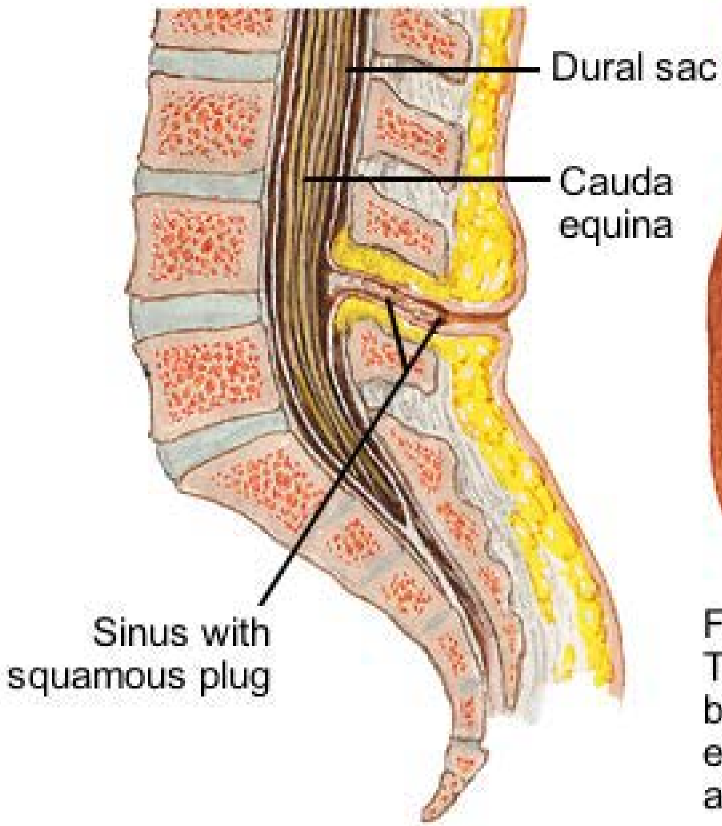


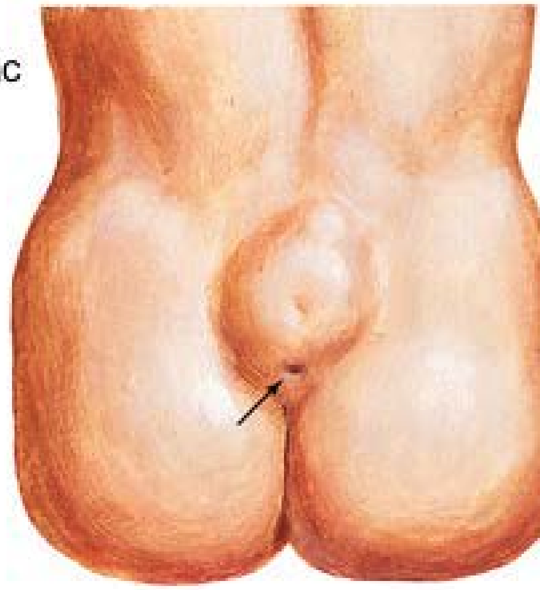
Neural Tube Defects

Spinal bifida occulta



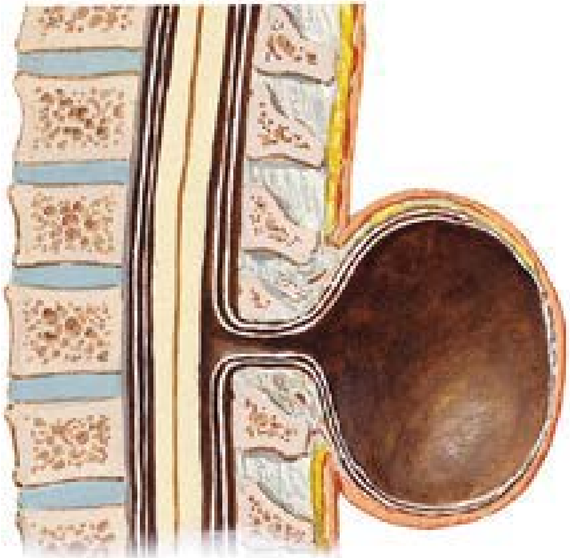
Dermal sinus



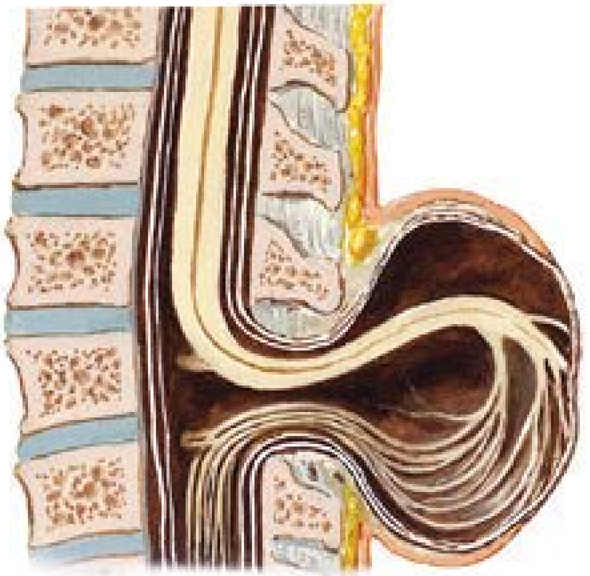


Fat pad overlying spina bifida occulta. Tuft of hair or only skin dimple may be present, or there may be no external manifestation. Dermal sinus also present in this case (arrow)

Types of spina bifida aperta with protrusion of spinal contents

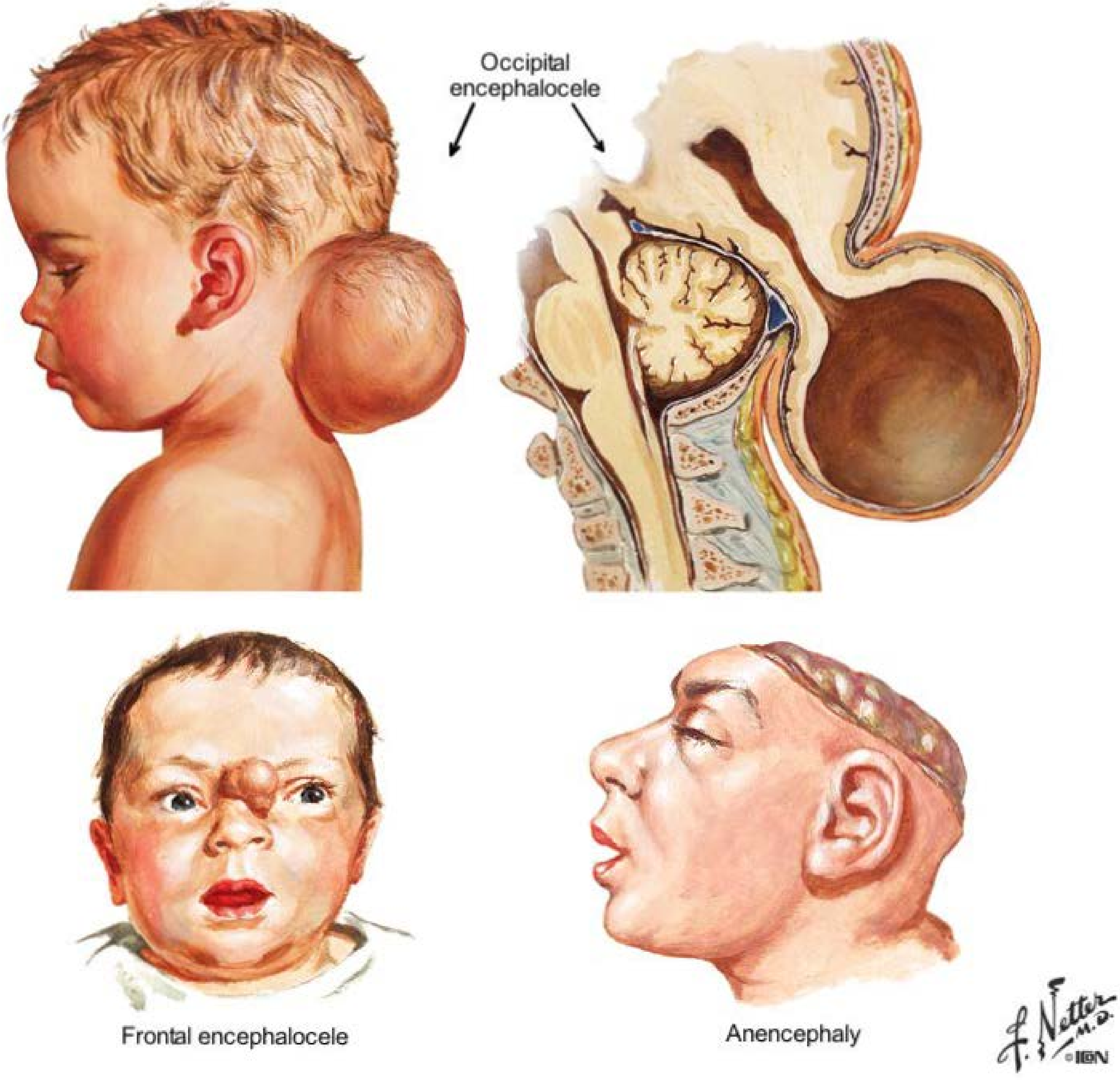


Meningocele

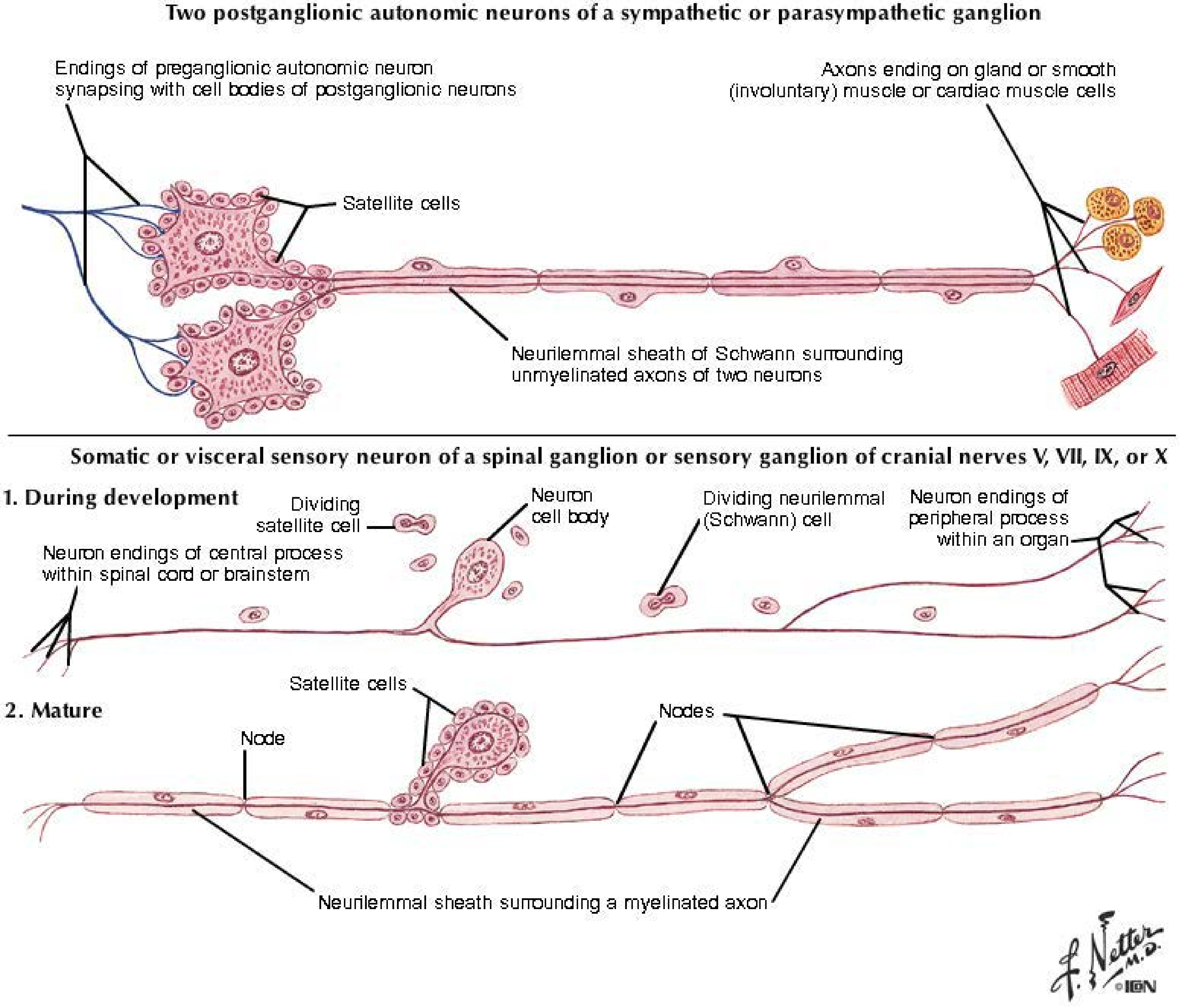


Meningomyelocele

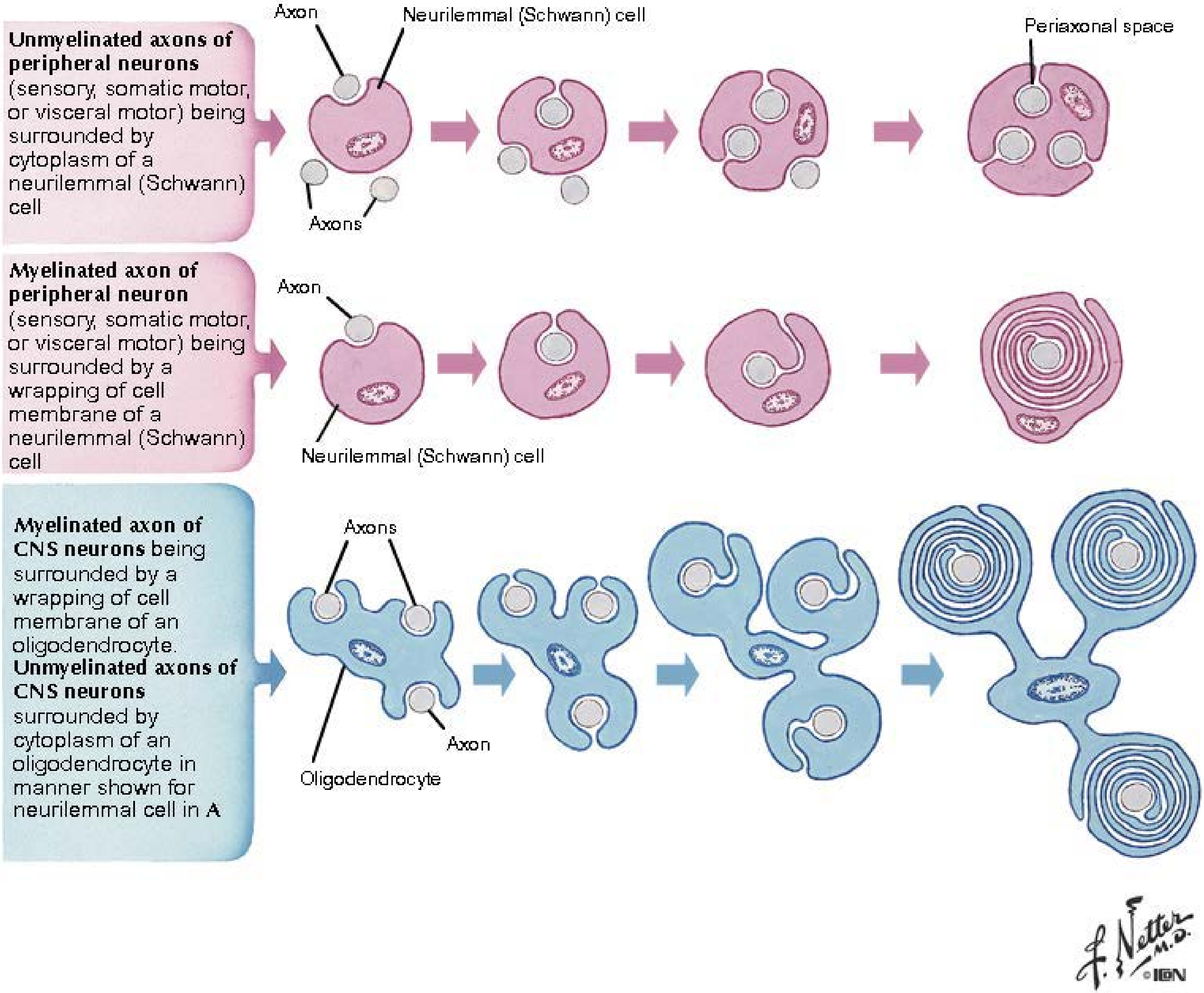
Neural Tube Defects



Neuron Development

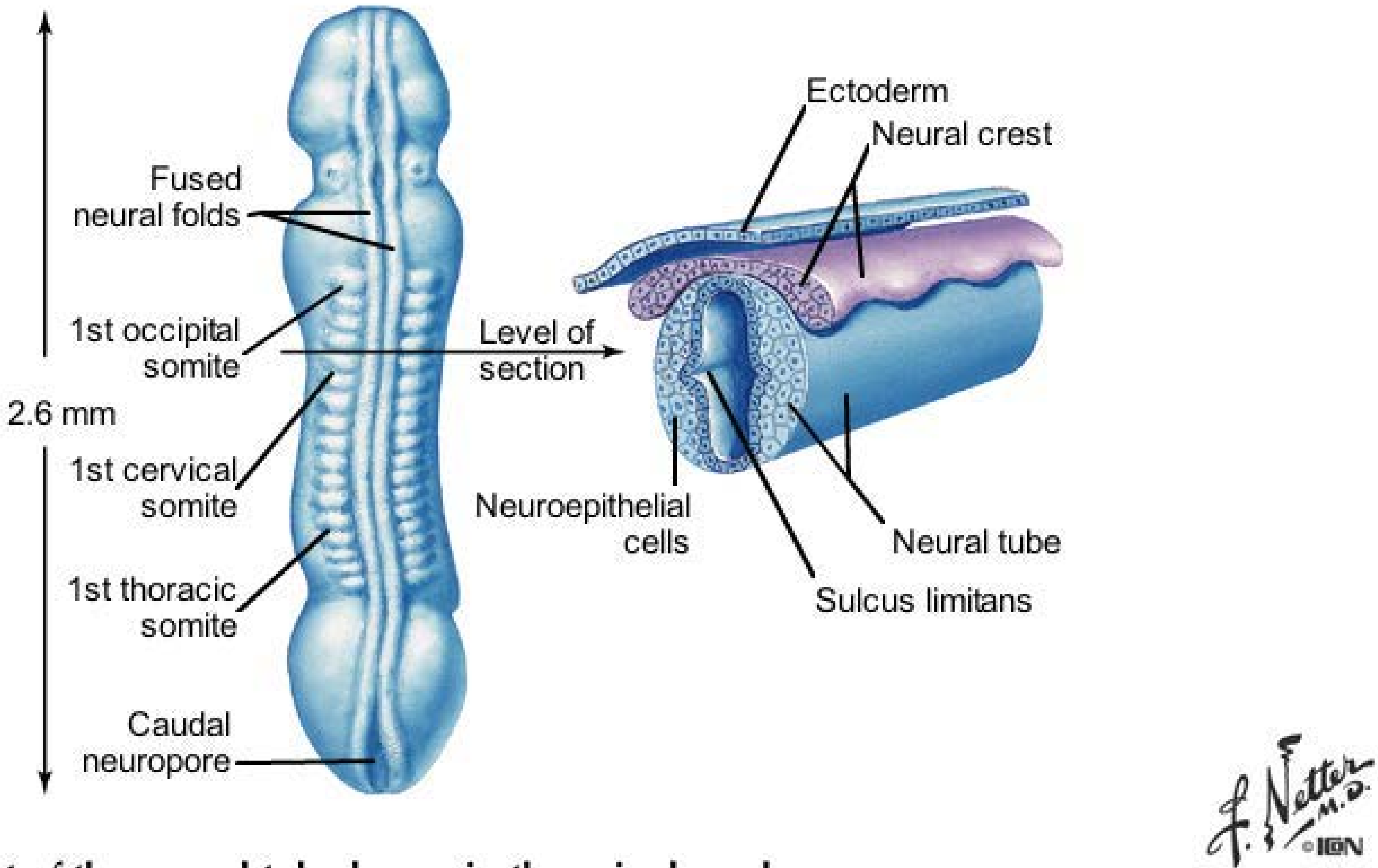


Development of the Cellular Sheath of Axons

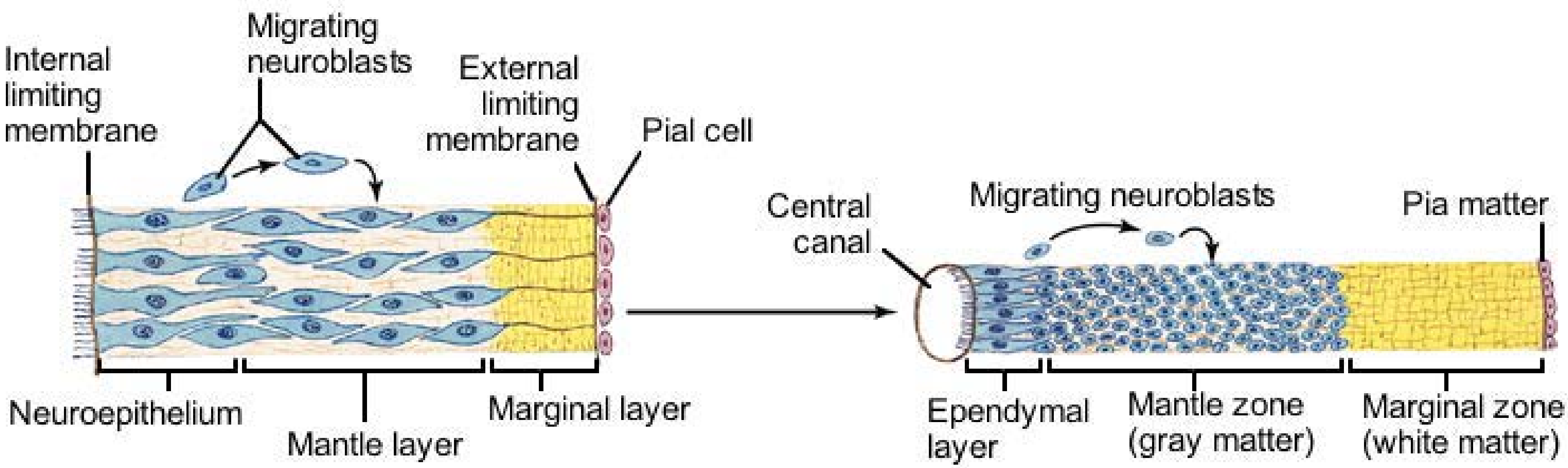


Development of the Spinal Cord Layers

Embryo at 24 days (dorsal view)



Development of the neural tube layers in the spinal cord

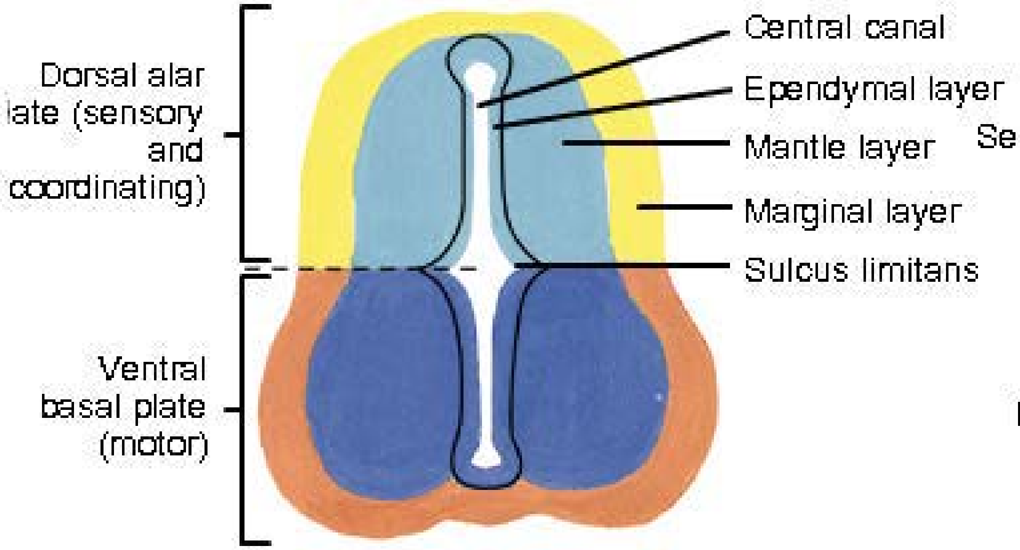


Neural tube at 5 weeks

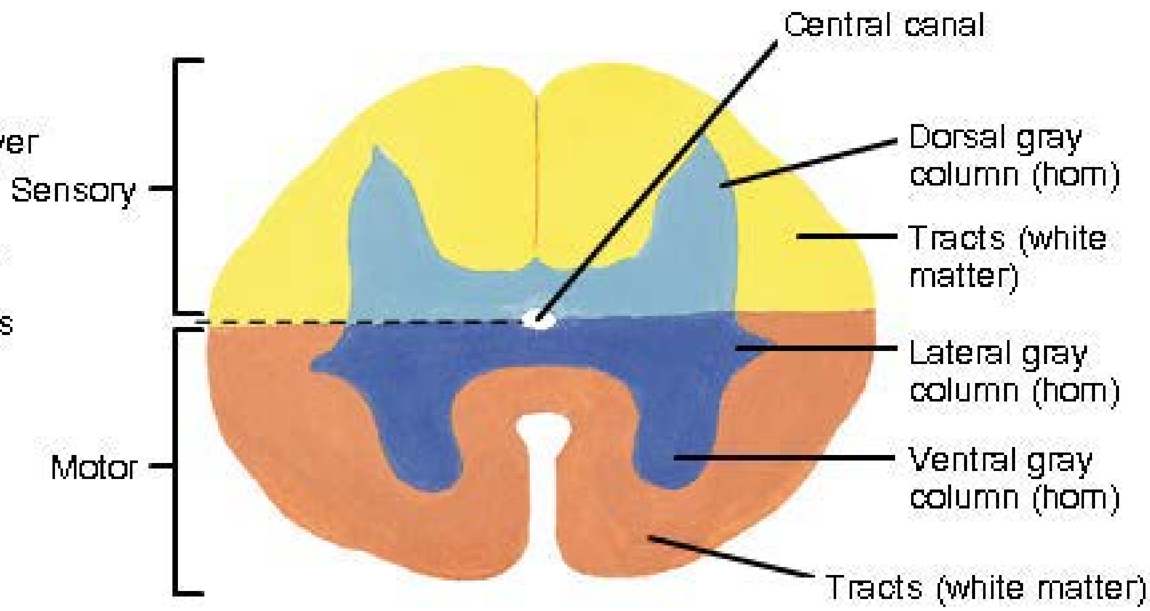
Spinal cord at 3 months

Development of the Spinal Cord

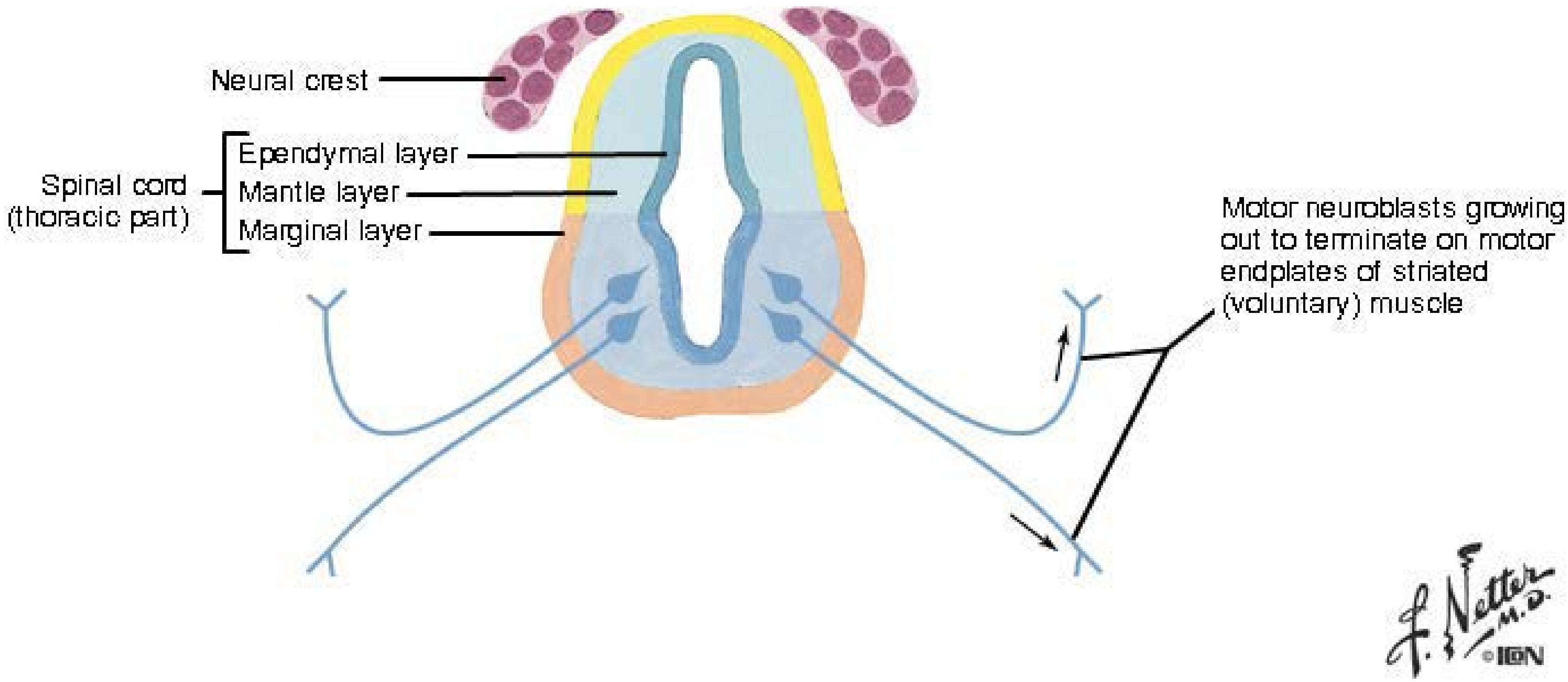
5 1/2 weeks (transverse section)



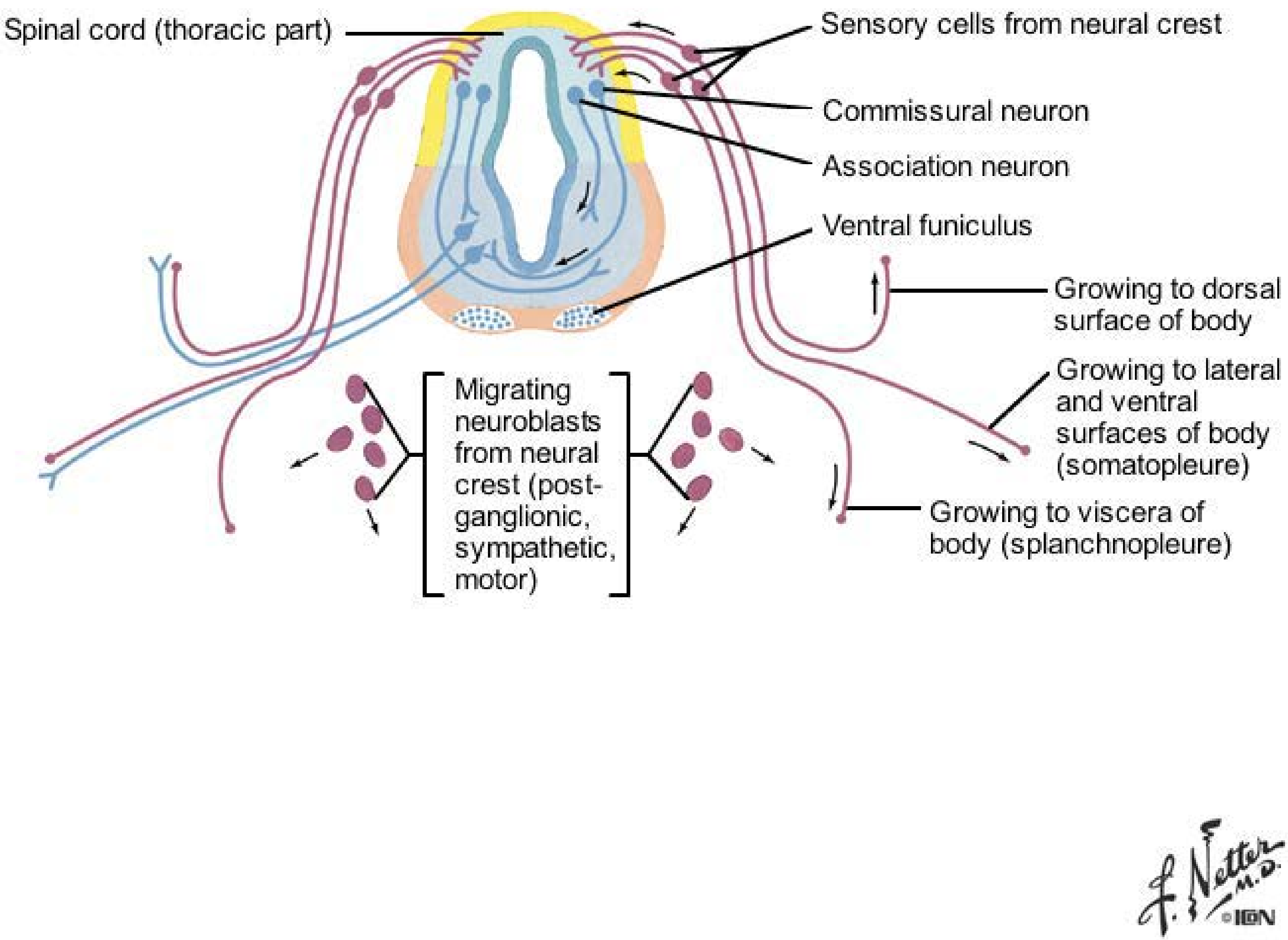
Mature (transverse section)



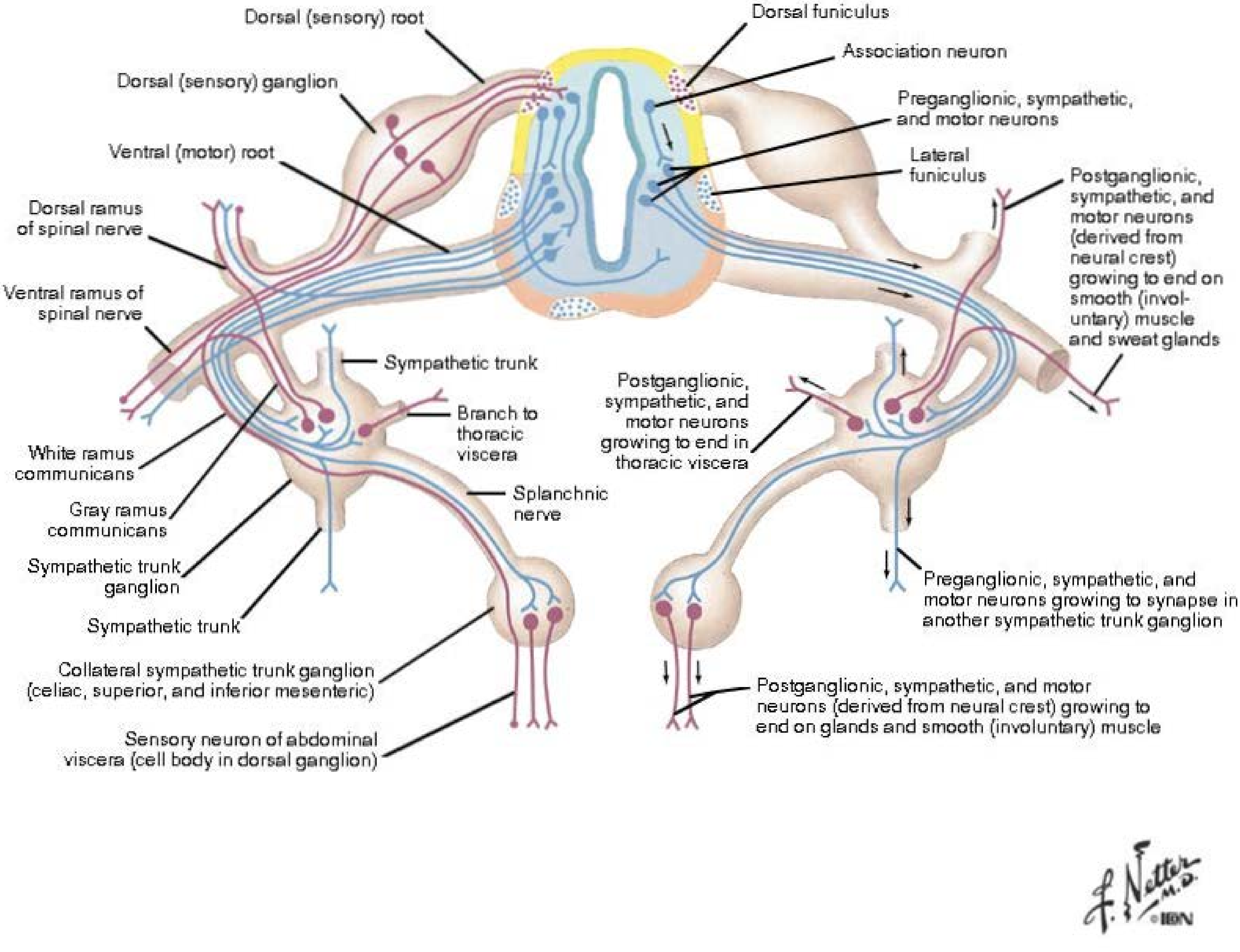
Differentiation and growth of neurons at 26 days



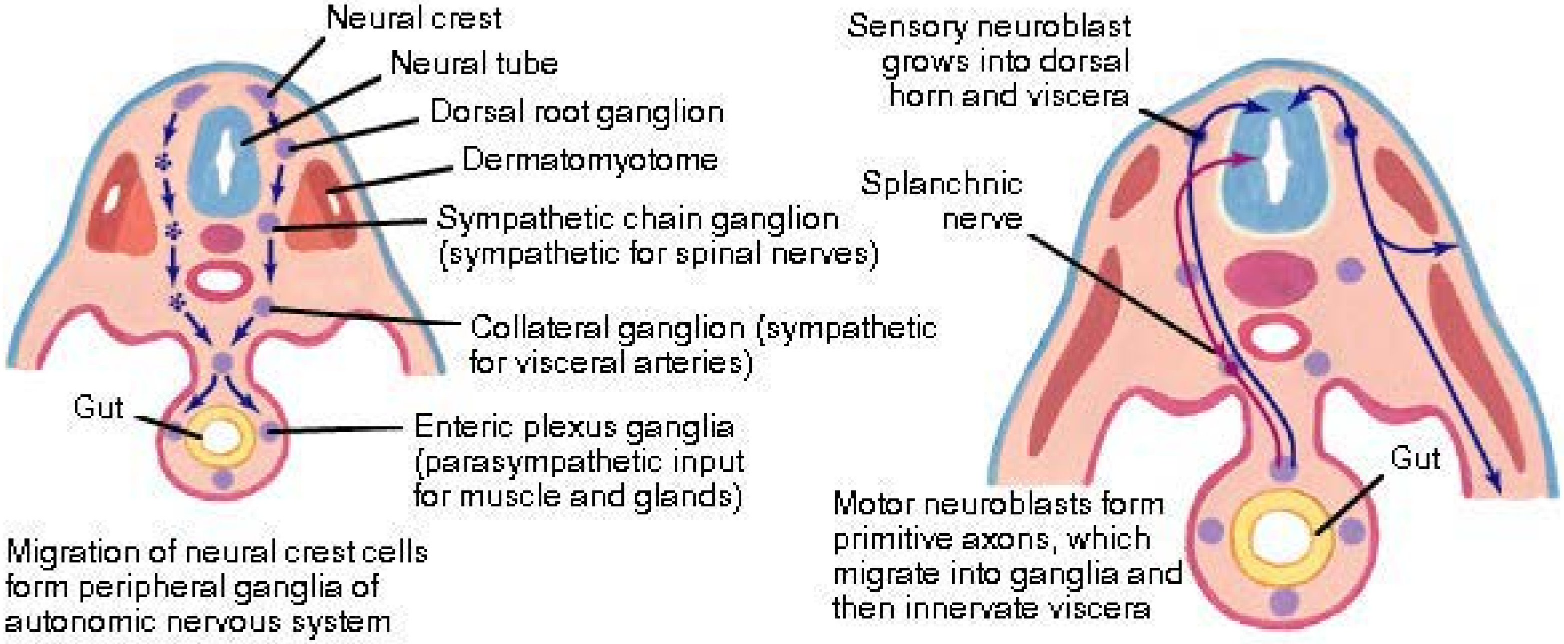
Peripheral Nervous System
Differentiation and growth of neurons at 28 days
(right side of diagram shows newly acquired neurons only)



Peripheral Nervous System
Differentiation and growth of neurons at 5 to 7 weeks
(right side of diagram shows neurons acquired since 28th day only)

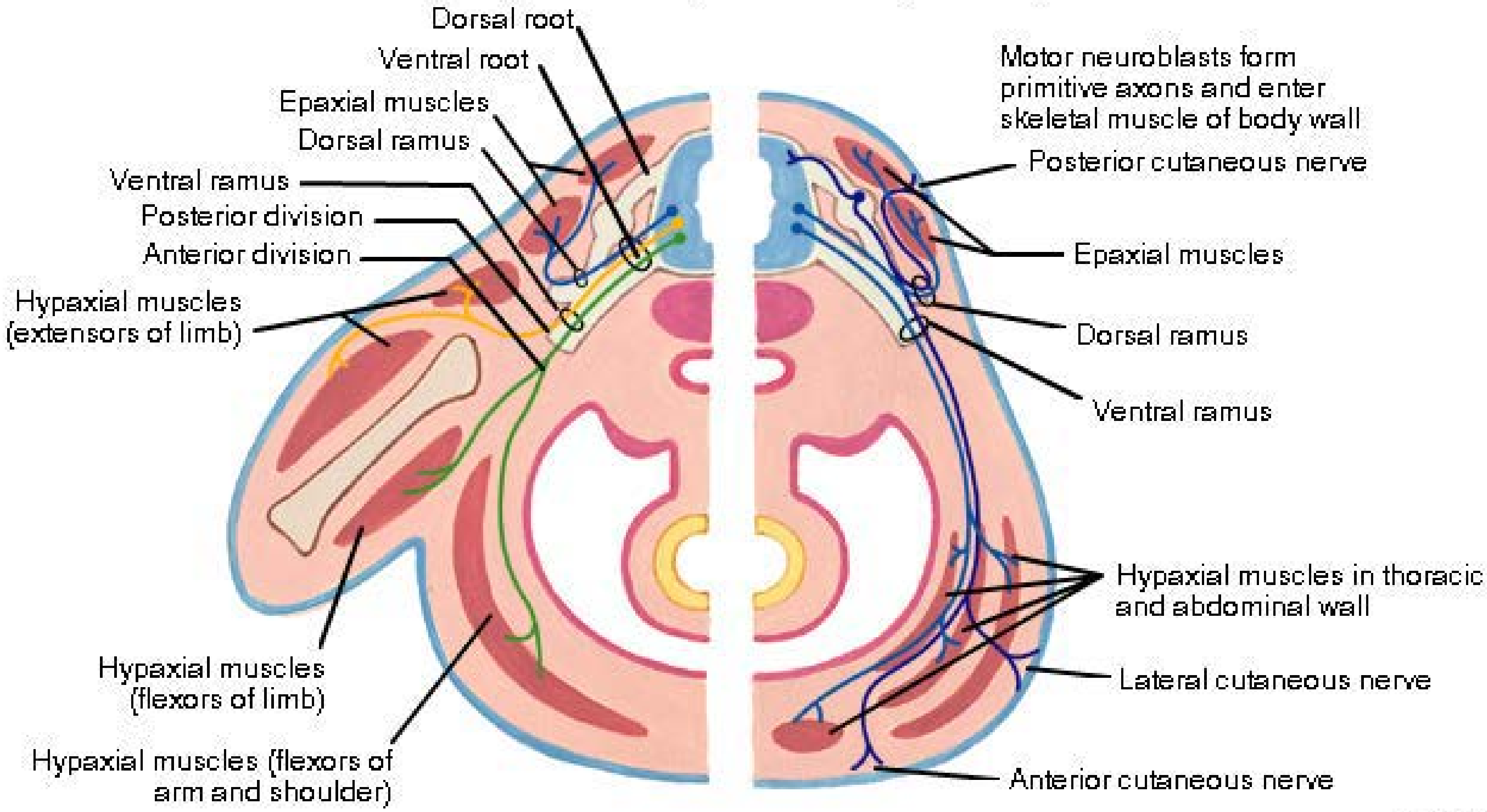


Peripheral Nervous System



Autonomic Development

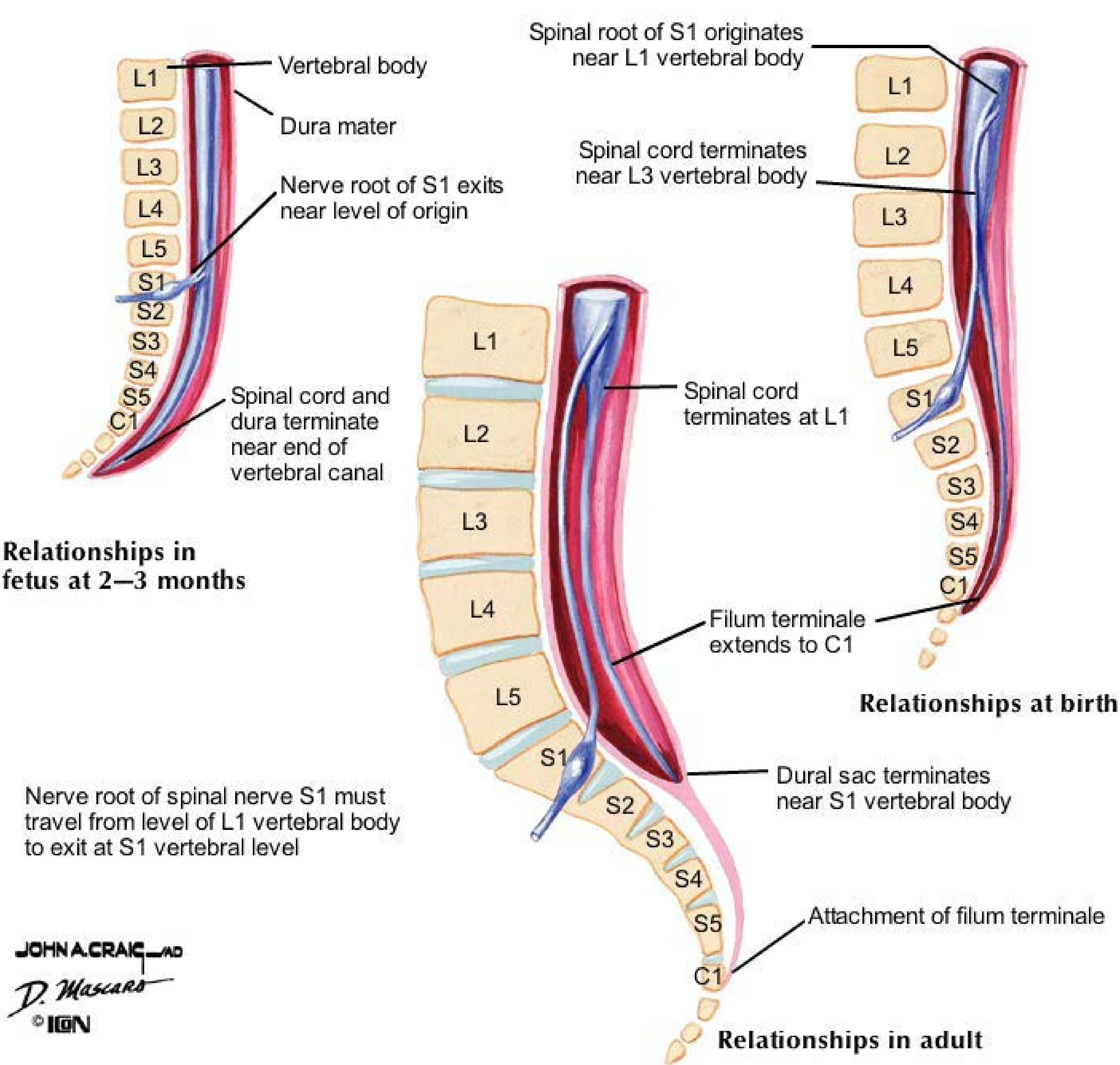
Autonomic nervous system mostly innervates splanchnopleure (viscera)



Somatic Development

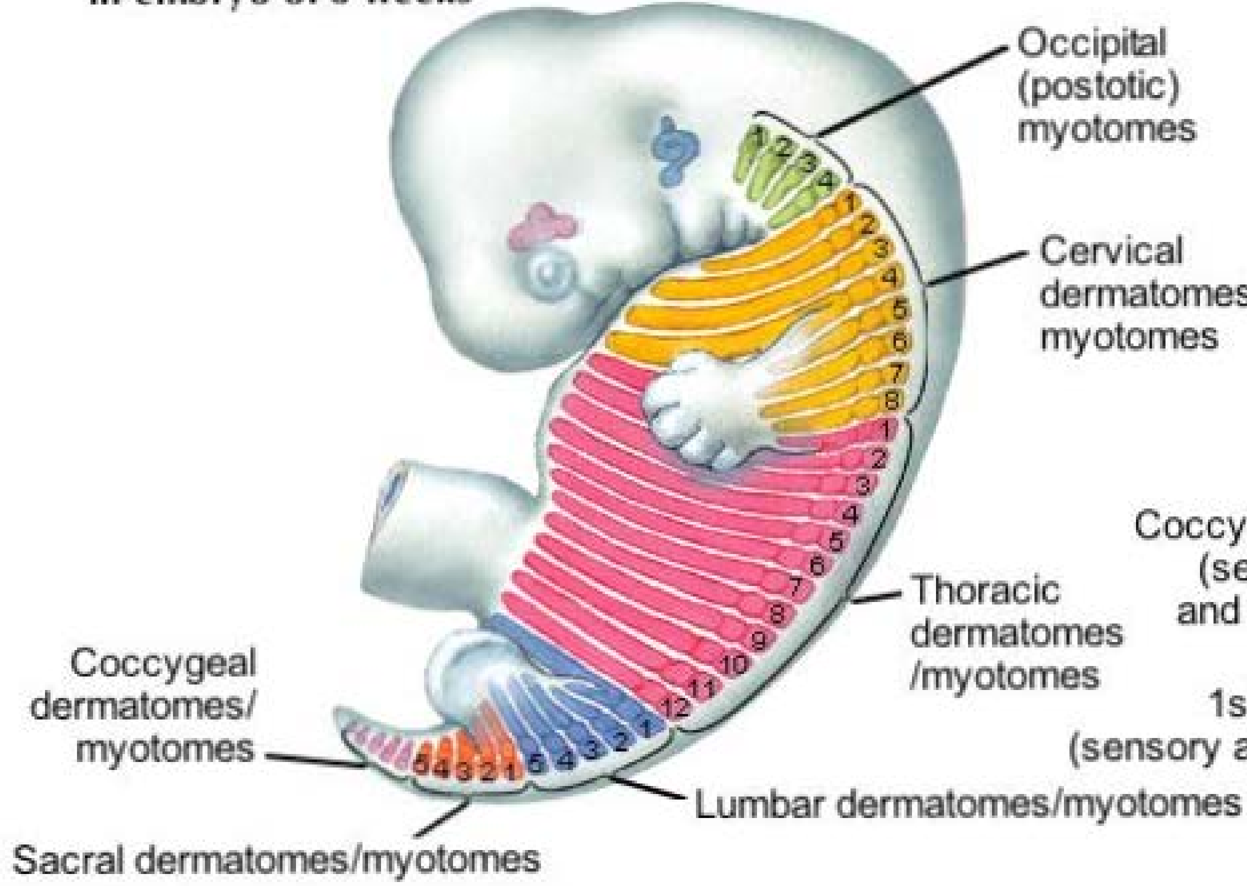
Somatic nervous system innervates somatopleure (body wall)

Growth of the Spinal Cord and Vertebral Column

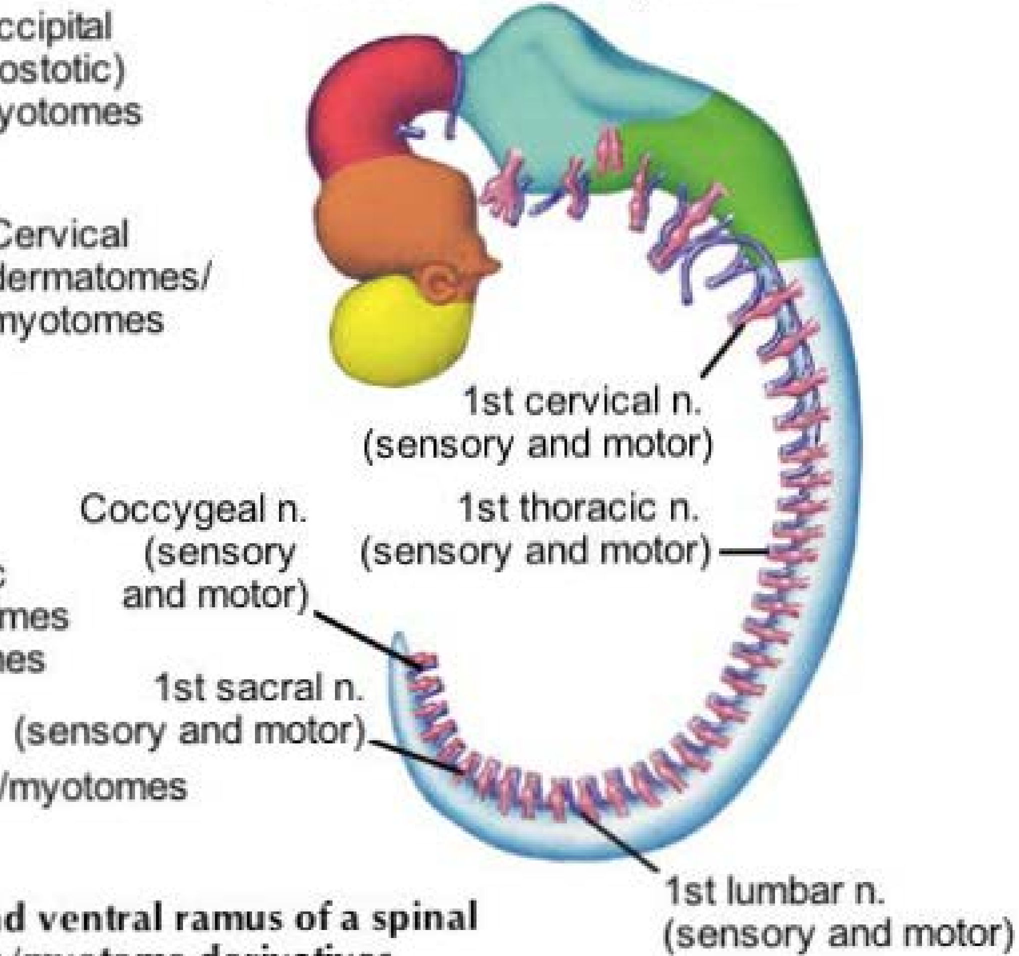


Embryonic Dermatomes

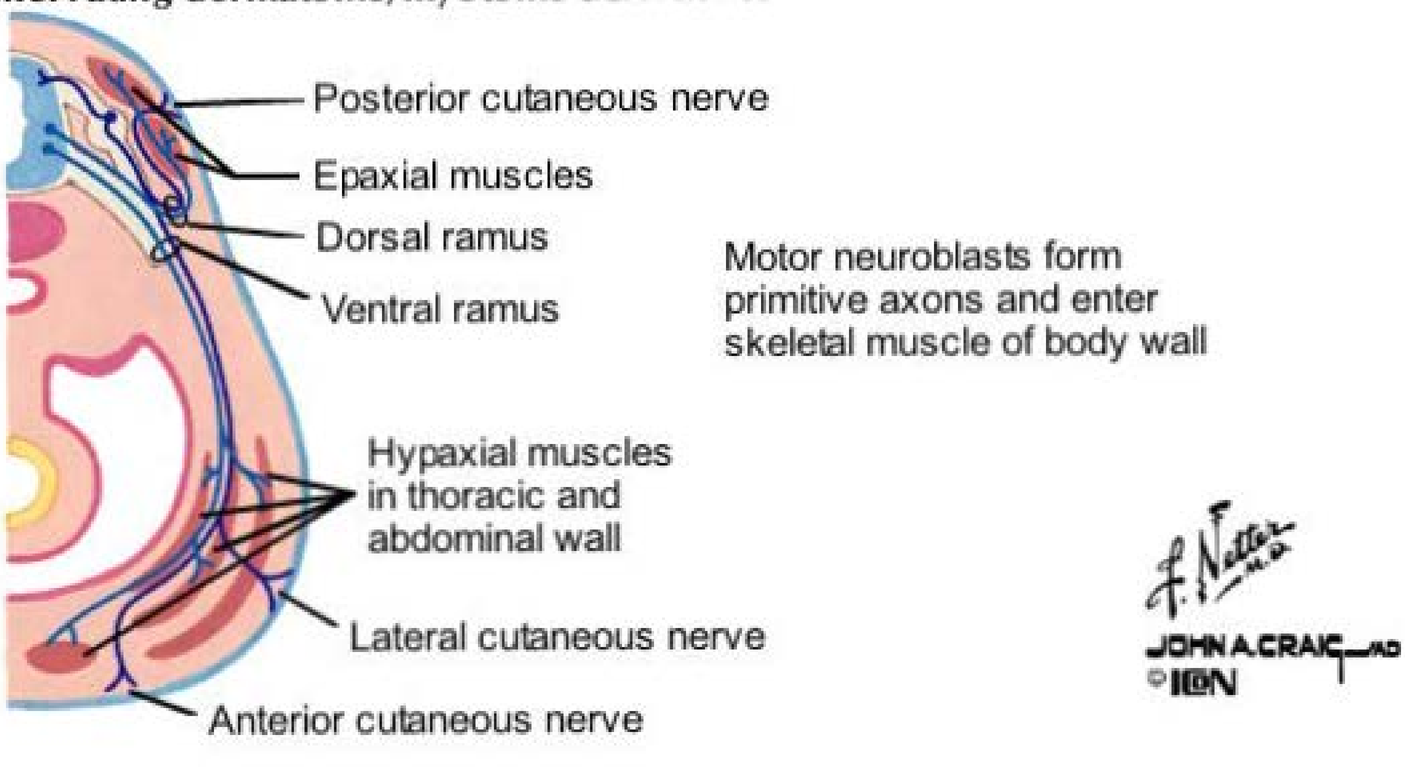
Segmental distribution of dermatomes/myotomes in embryo of 6 weeks



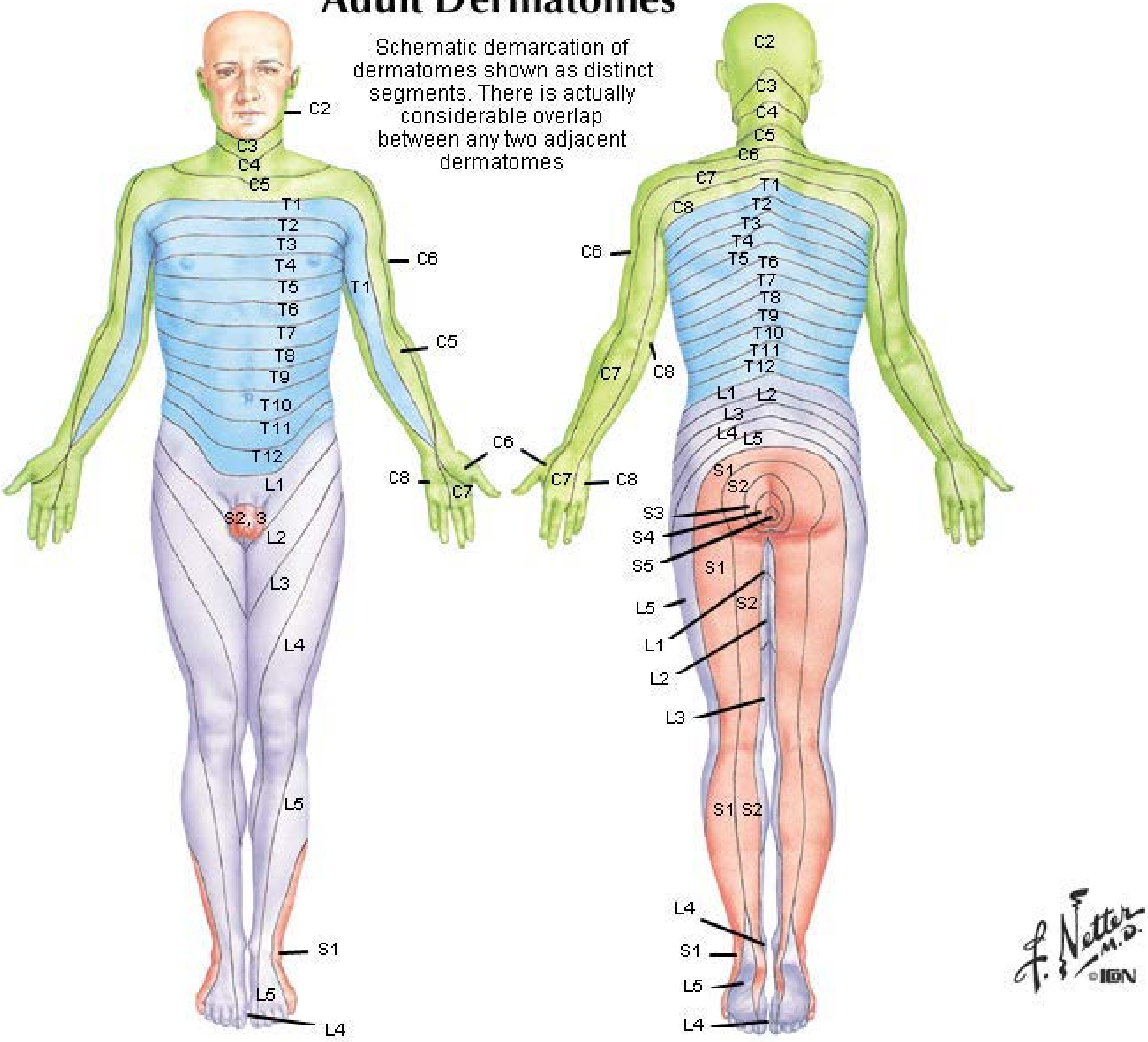
One pair of spinal nerves relates to each of the dermatomes/myotomes



Cross section of the dorsal and ventral ramus of a spinal nerve innervating dermatome/myotome derivatives



Adult Dermatomes



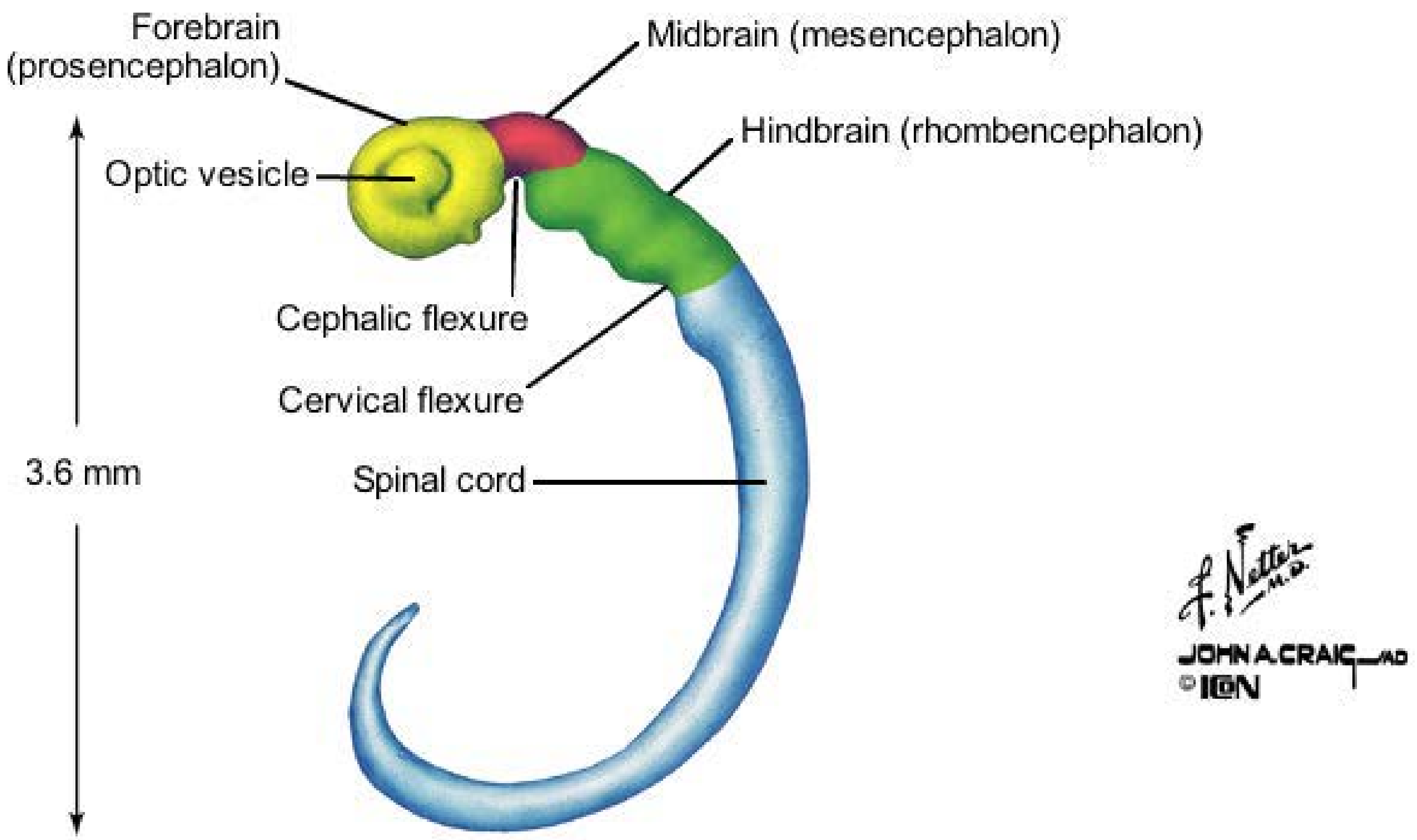
Schematic demarcation of dermatomes shown as distinct segments. There is actually considerable overlap between any two adjacent dermatomes

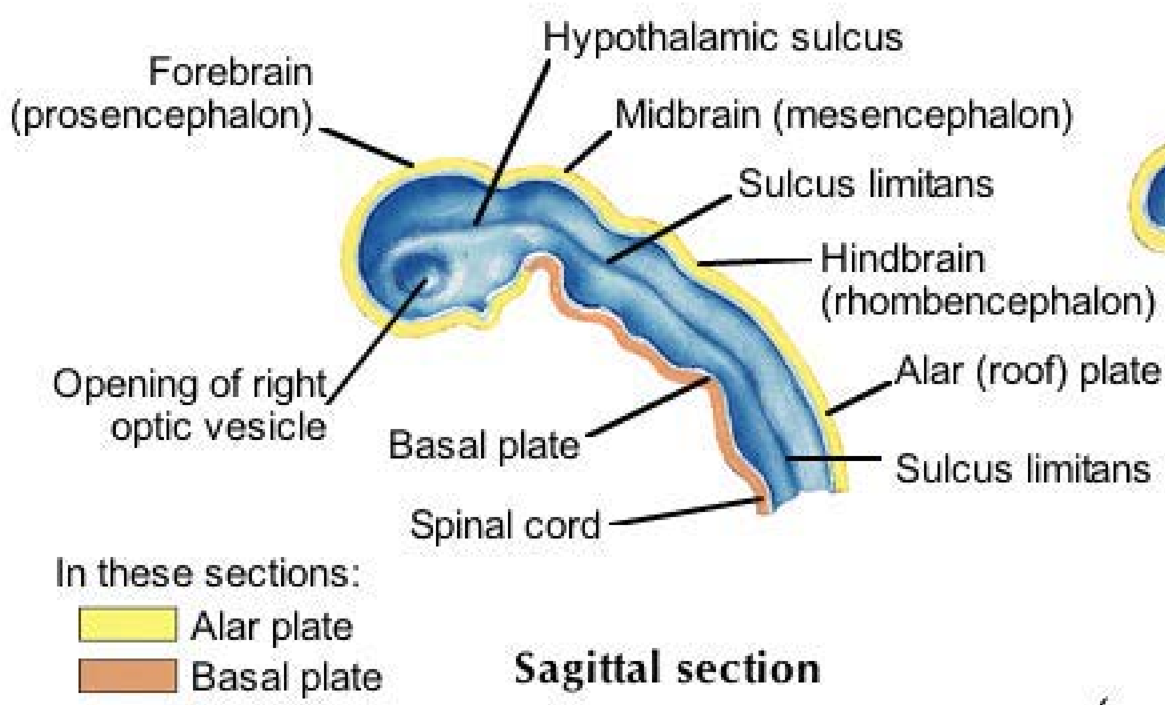
Levels of principal dermatomes

C5	Clavicles
C5, 6, 7	Lateral parts of upper limbs
C8, T1	Medial sides of upper limbs
C6	Thumb
C6, 7, 8	Hand
C8	Ring and little fingers
T4	Level of nipples
T10	Level of umbilicus
T12	Inguinal or groin regions
L1, 2, 3, 4	Anterior and inner surfaces of lower limbs
L4, 5, S1	Foot
L4	Medial side of great toe
S1, 2, L5	Posterior and outer surfaces of lower limbs
S1	Lateral margin of foot and little toe
S2, 3, 4	Perineum

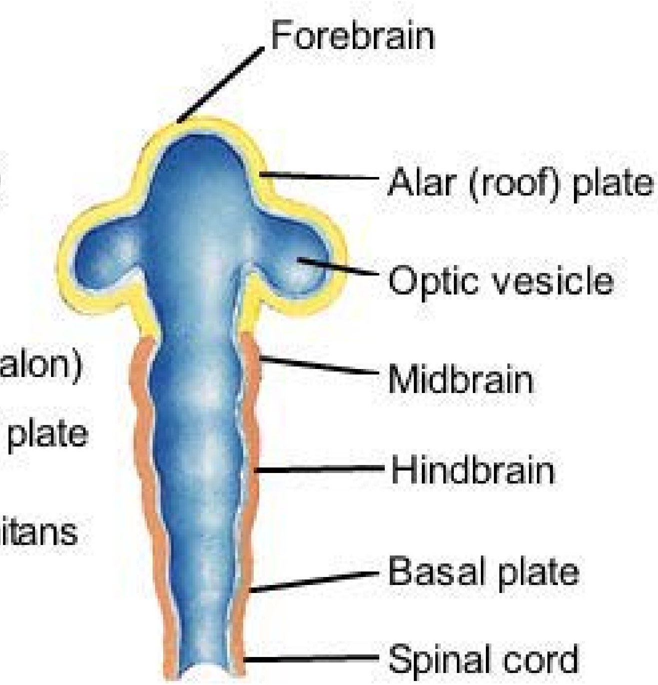
Development of the Brain

Central nervous system at 28 days



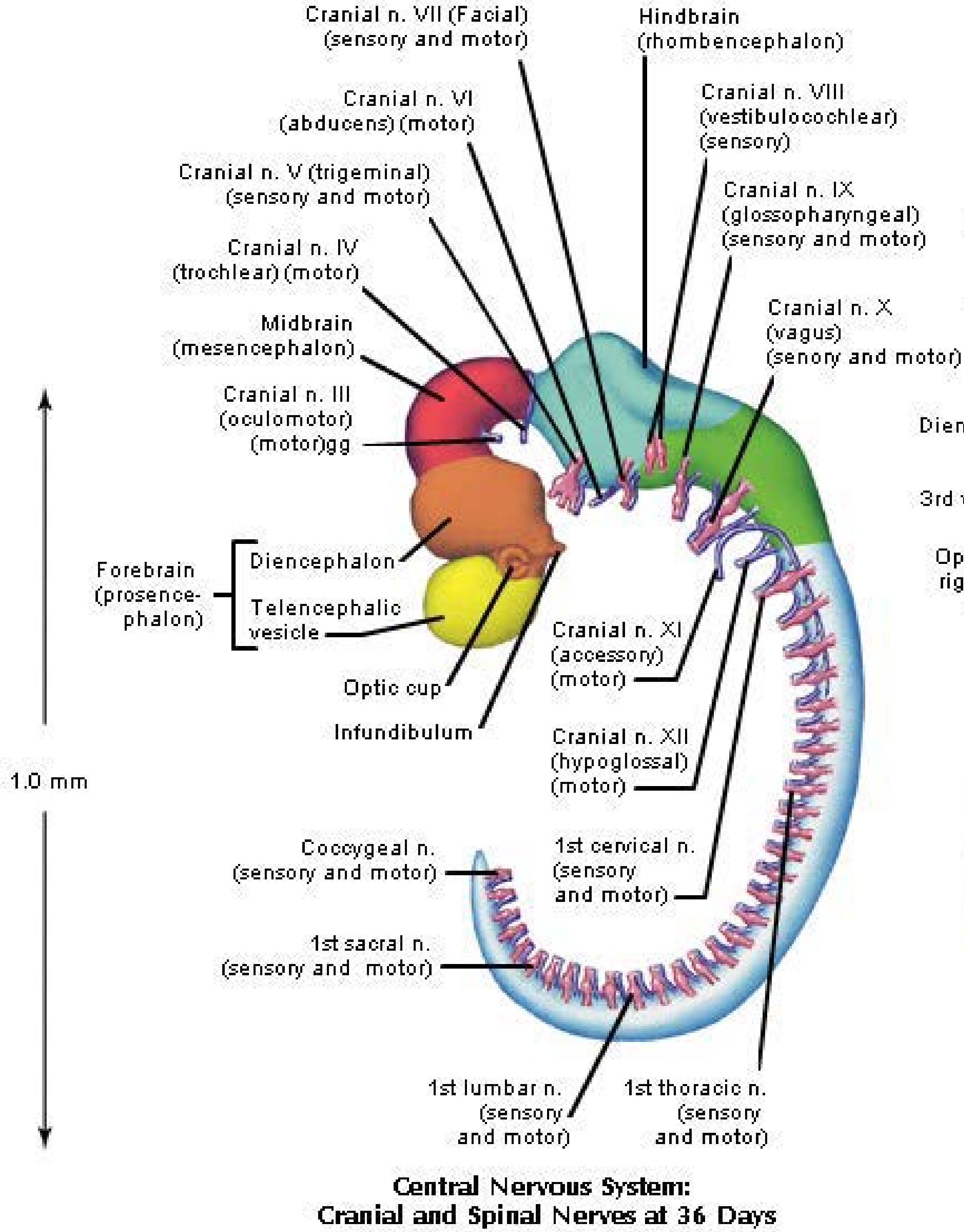


Sagittal section

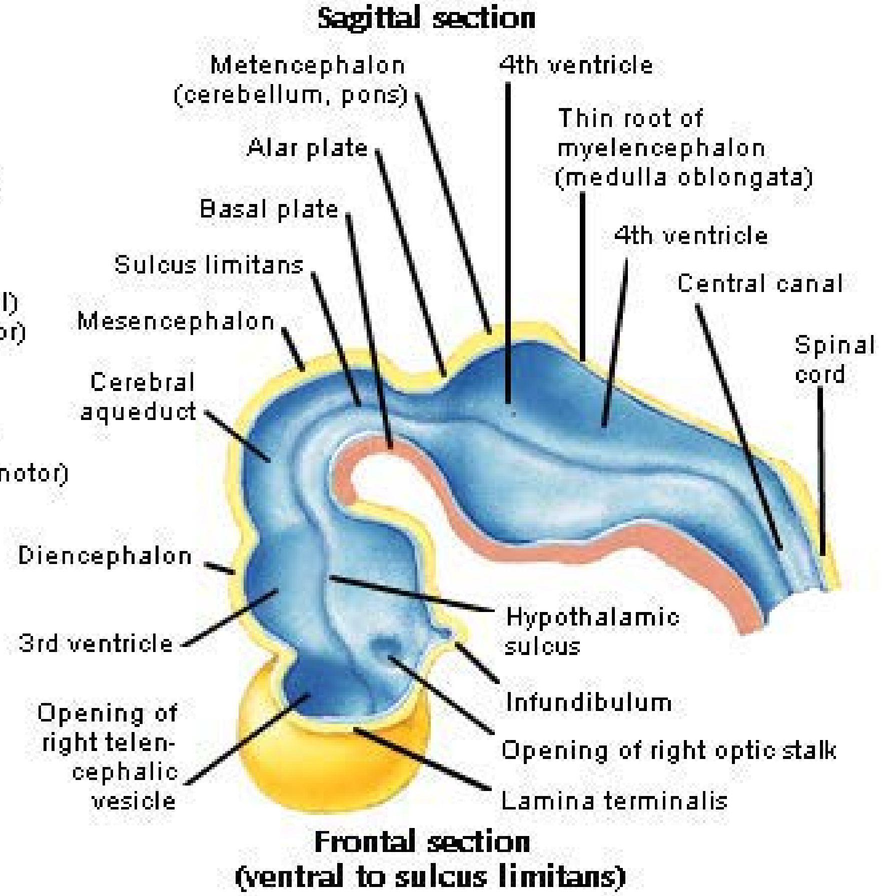


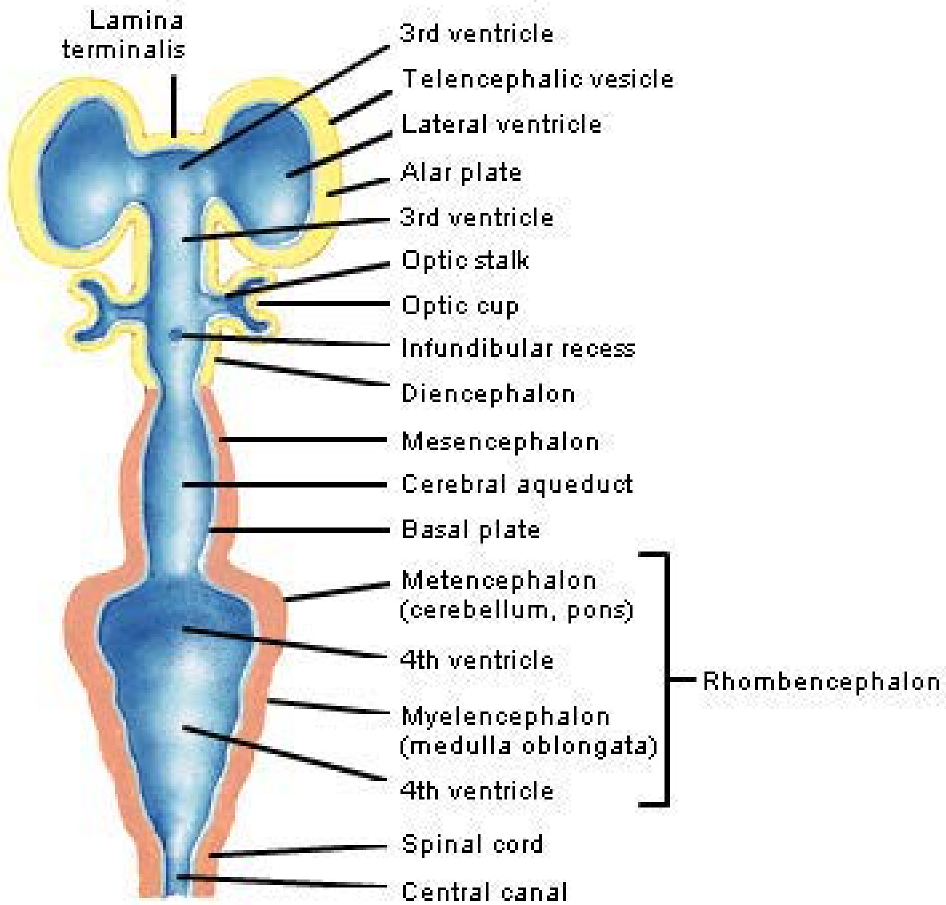
Frontal section (ventral to sulcus limitans)

Development of the Brain



Central Nervous System: Cranial and Spinal Nerves at 36 Days





In sagittal and frontal sections:

- Alar (roof) plate
- Basal plate
- Derivatives of neural crest

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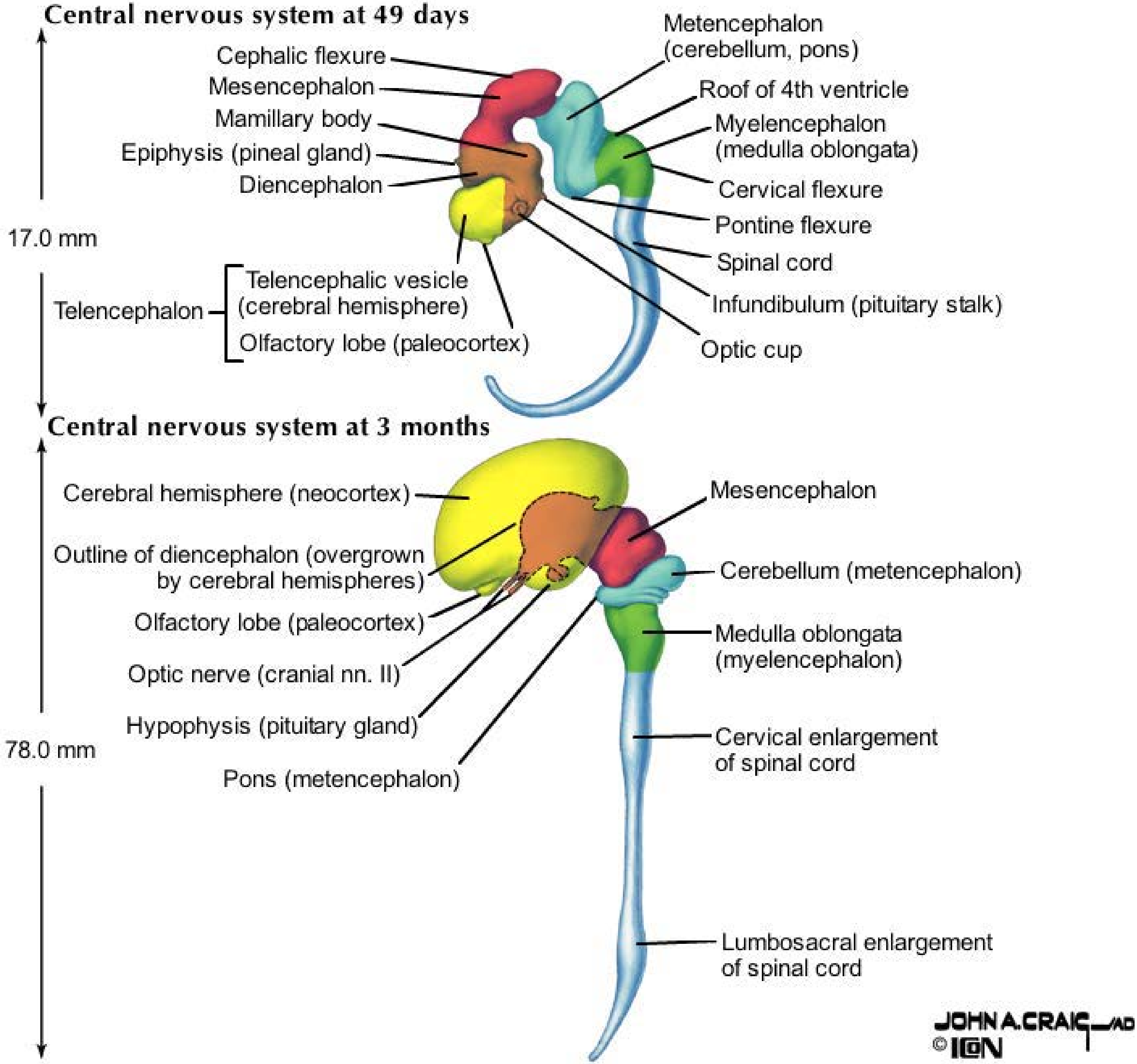
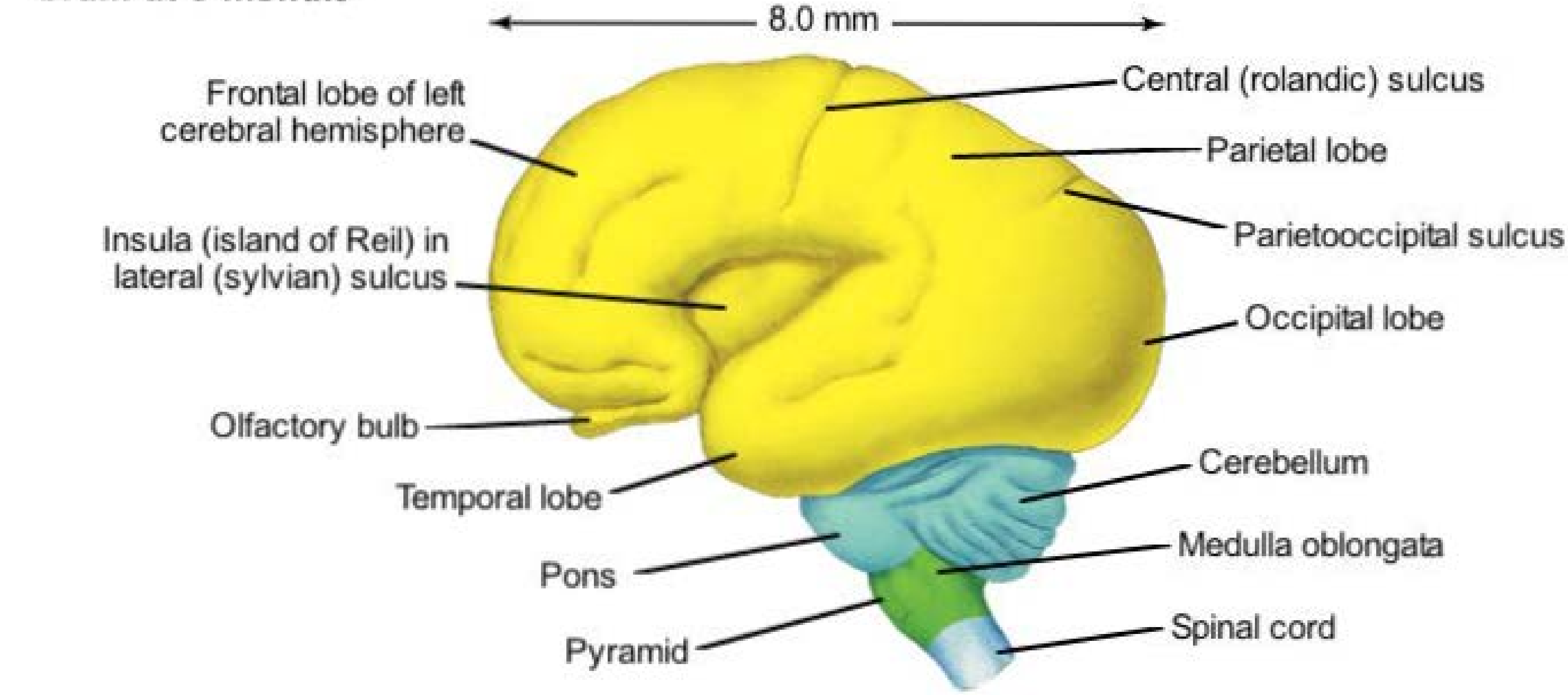
Development of the Brain

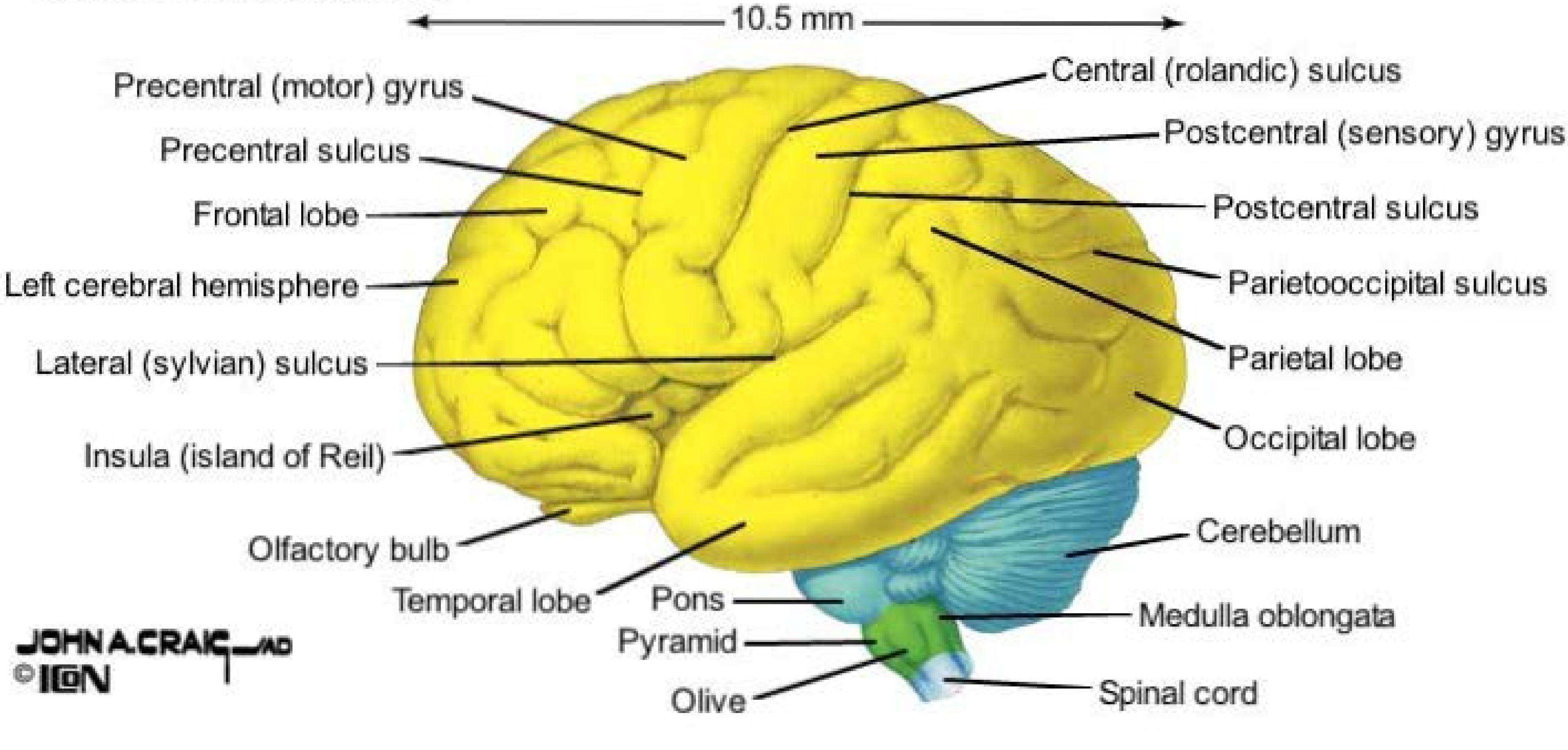


Growth of the Cerebral Hemispheres

Brain at 6 months

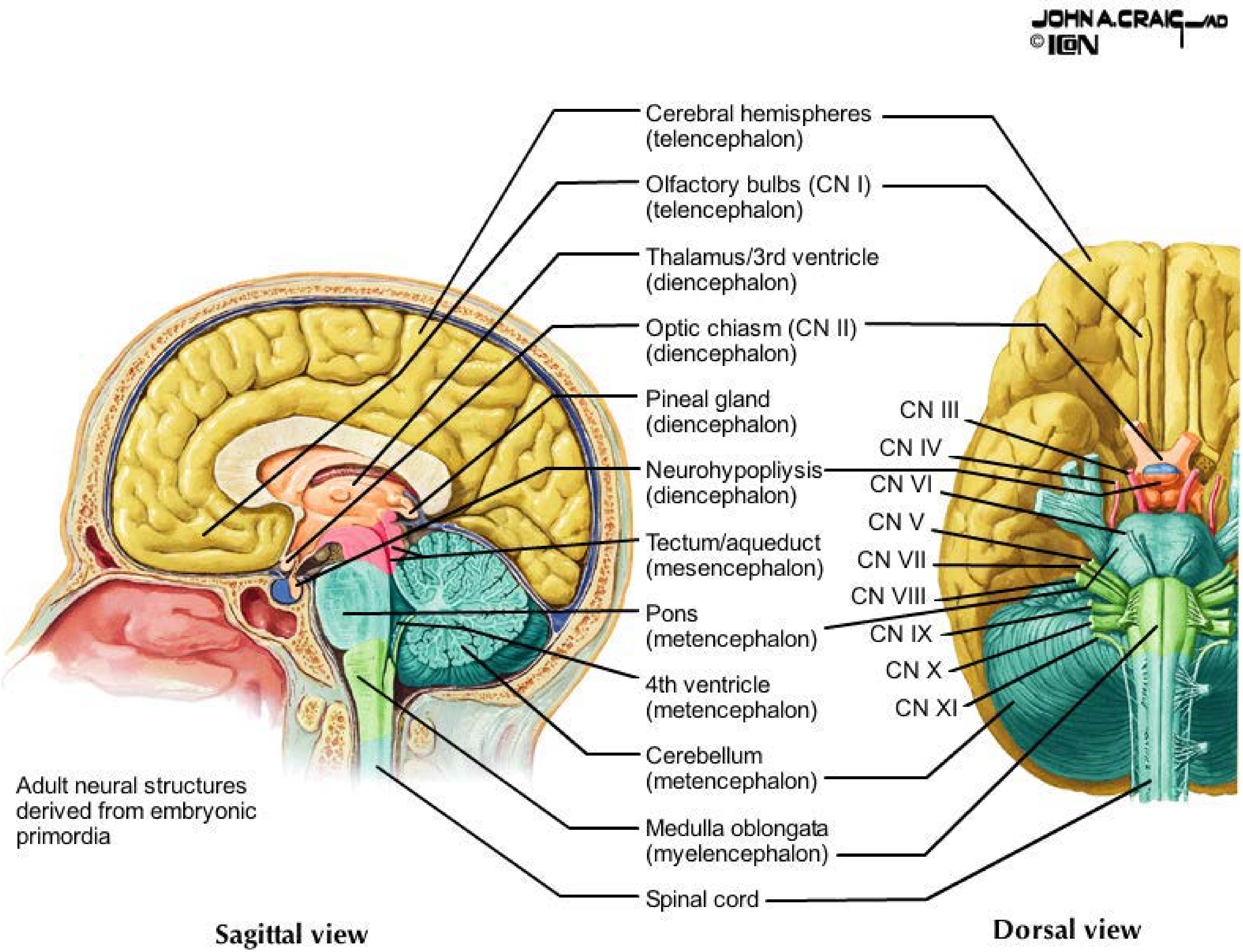


Brain at 9 months (birth)

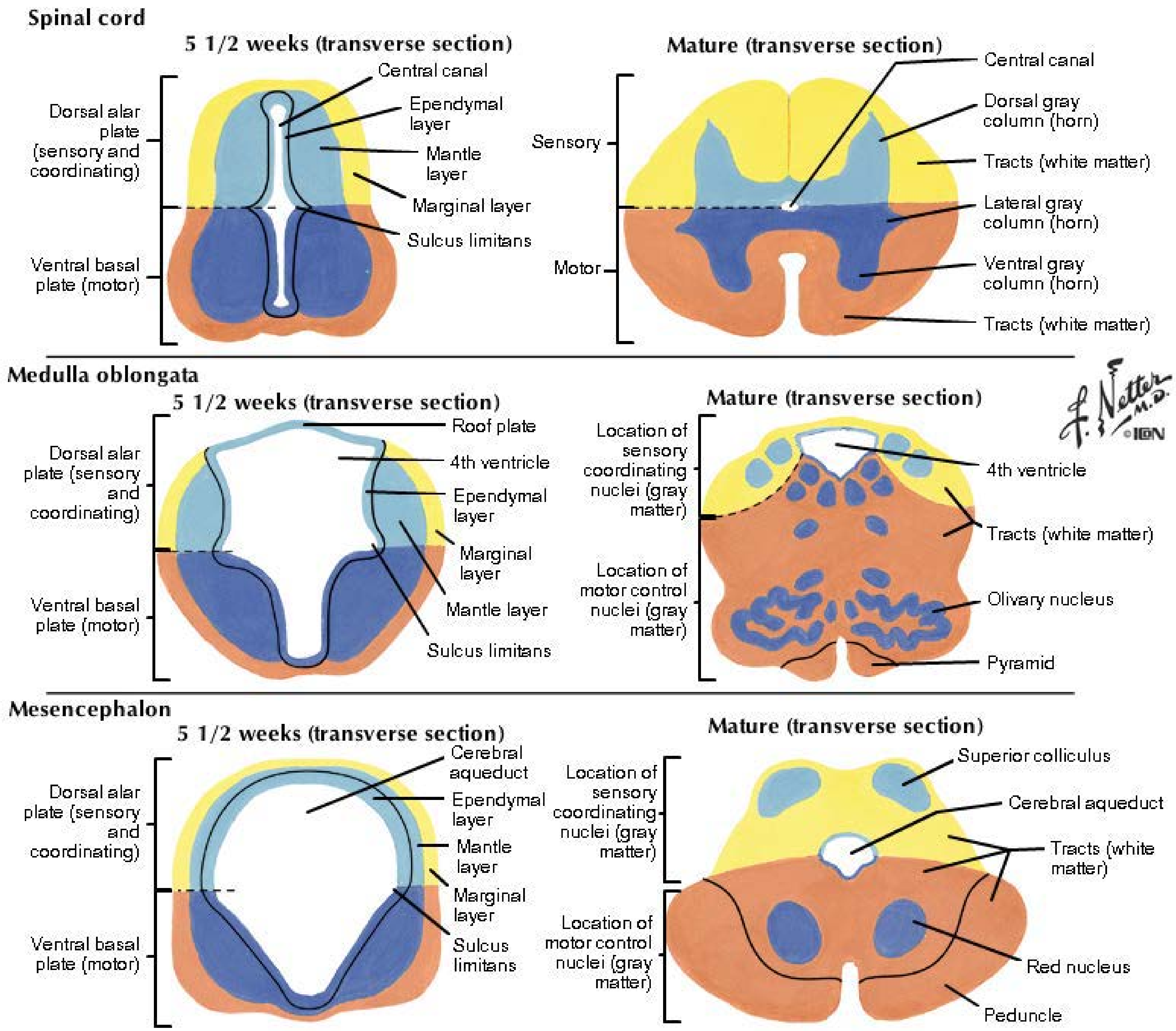


Derivatives of the Forebrain, Midbrain, and Hindbrain

Adult derivatives of brain primordia

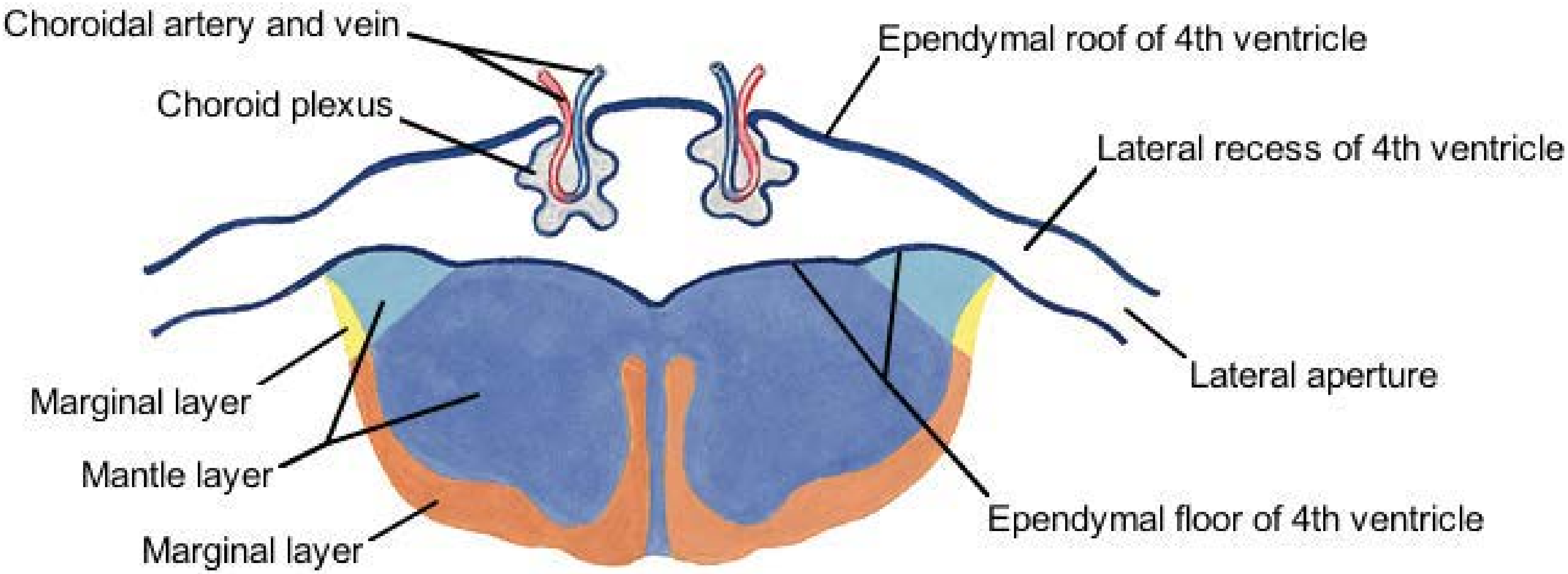


Cross Sections of the Midbrain and Hindbrain

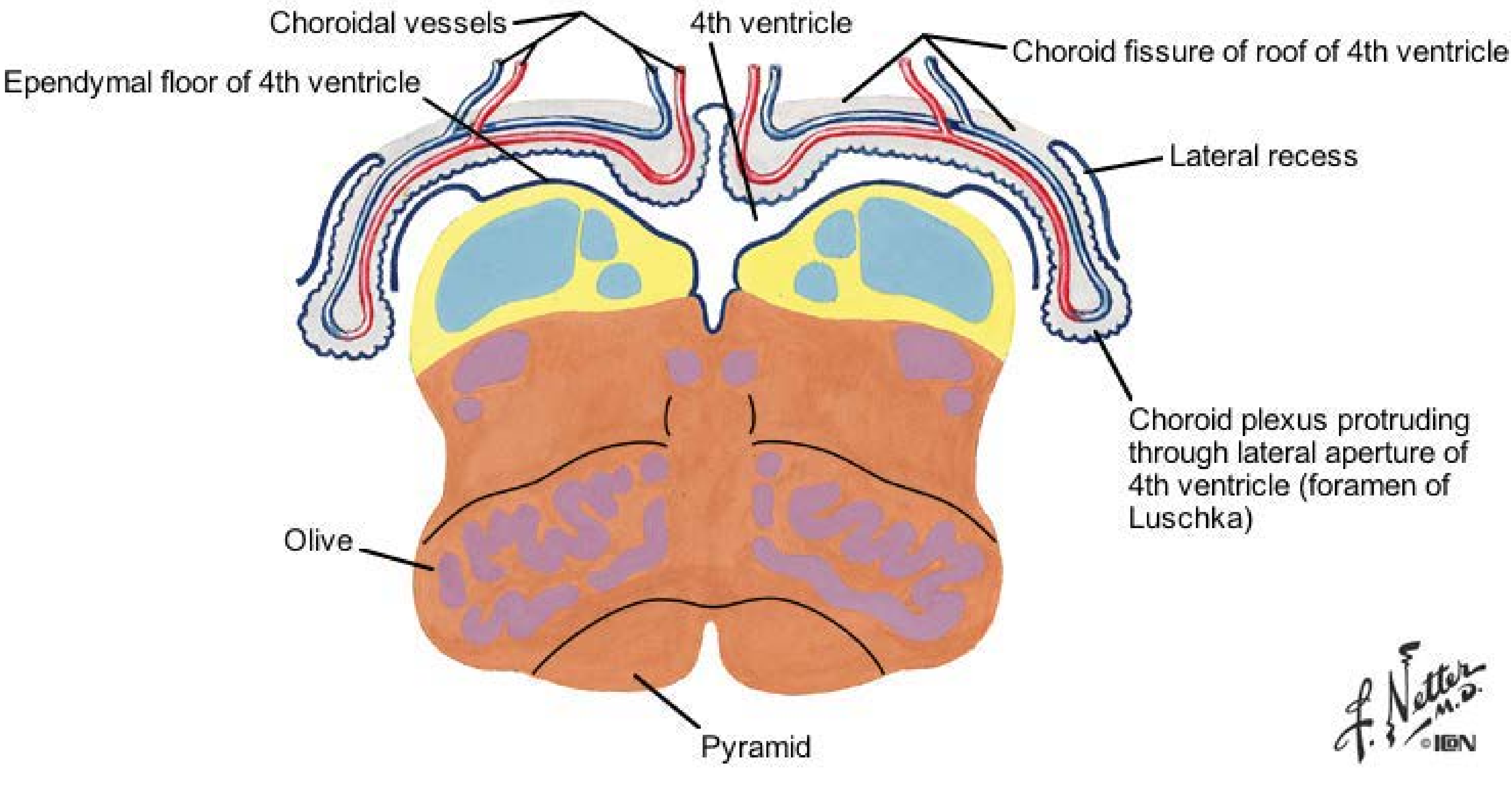


Production of Cerebrospinal Fluid

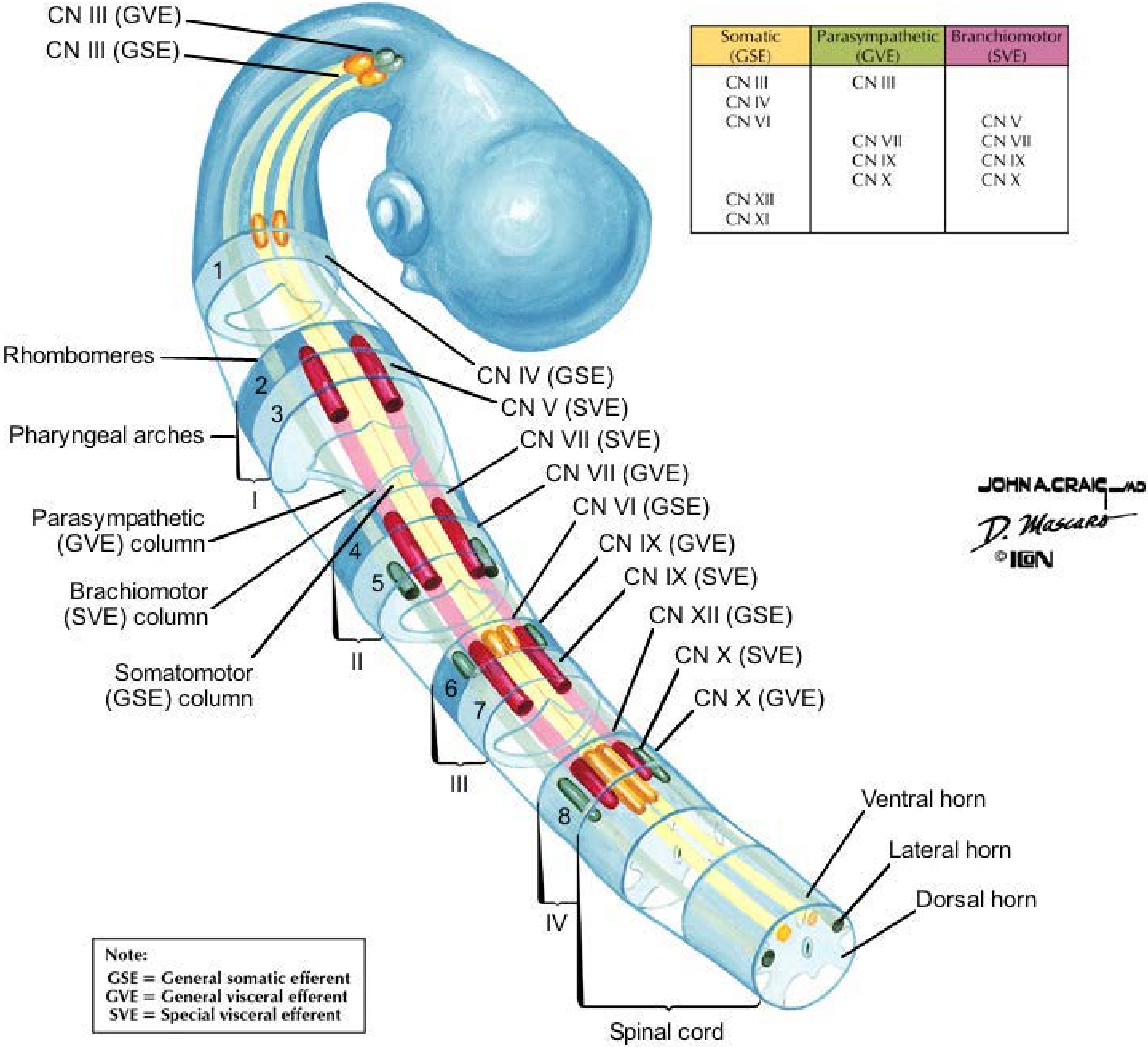
Medulla oblongata at 3 1/2 months (transverse section)



Medulla oblongata, mature (transverse section)



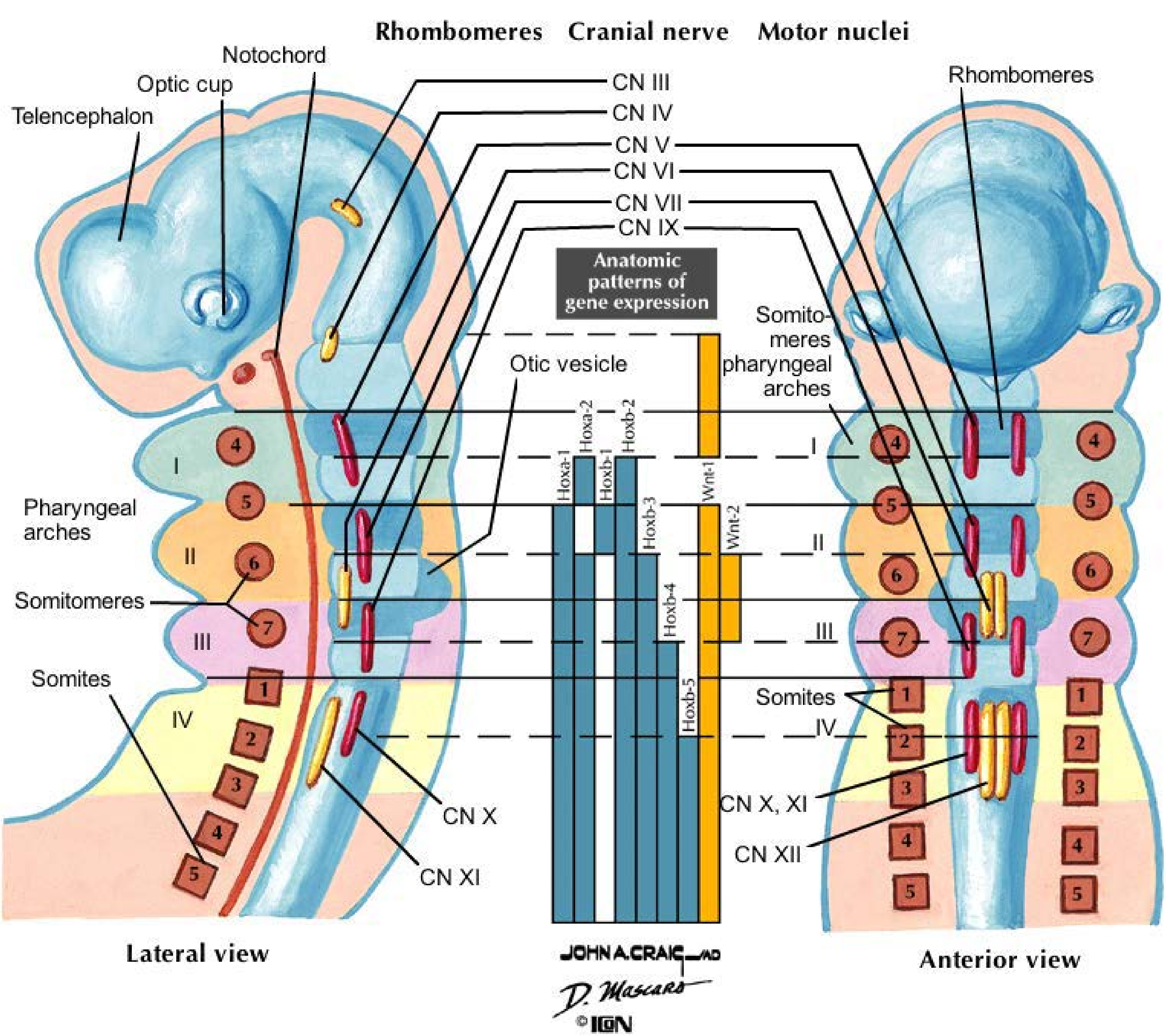
Development of Motor Nuclei in the Brainstem



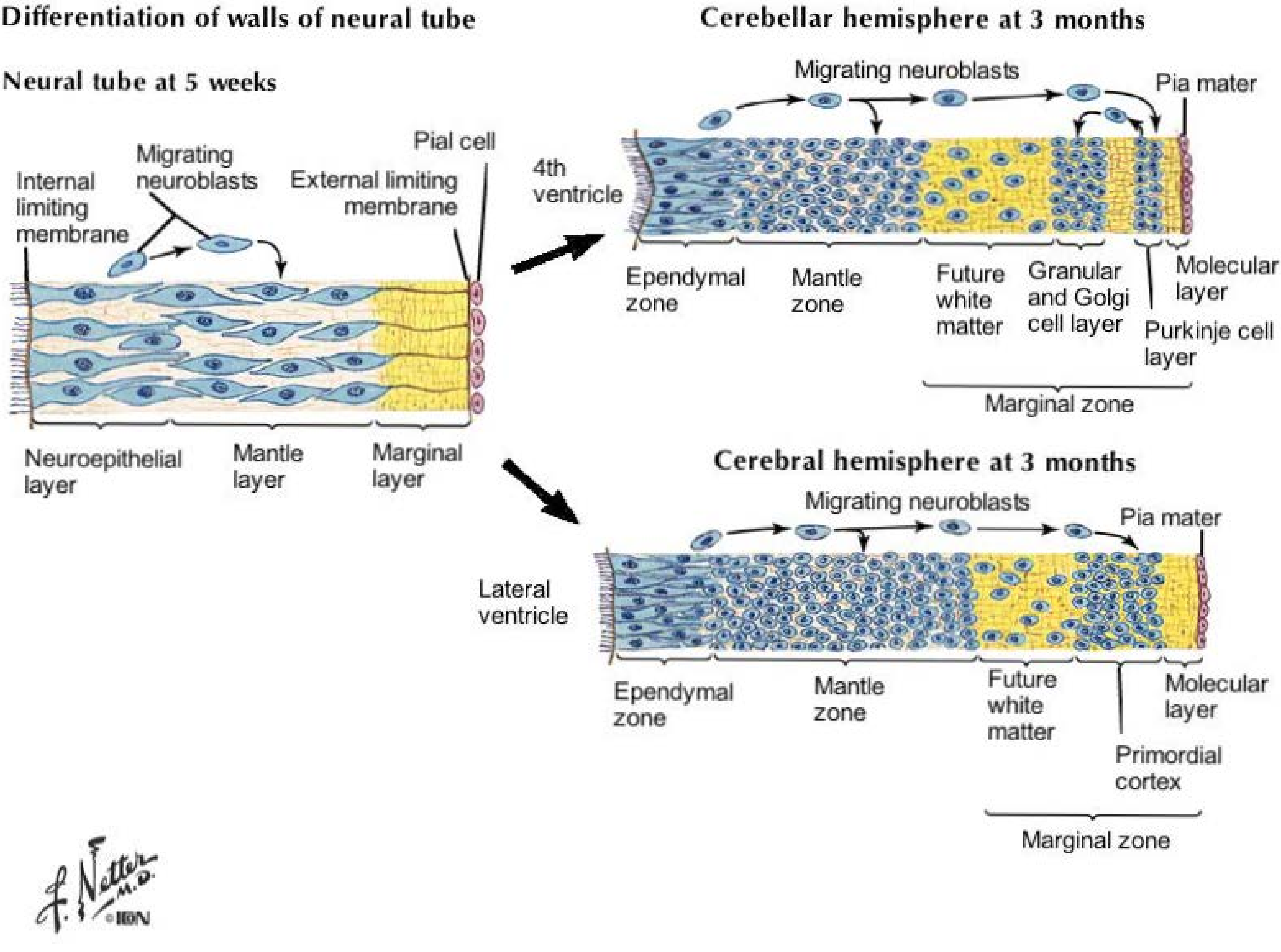
Somatic (GSE)	Parasympathetic (GVE)	Branchiomotor (SVE)
CN III	CN III	
CN IV		
CN VI		CN V
	CN VII	CN VII
	CN IX	CN IX
	CN X	CN X
CN XII		
CN XI		

Note:
GSE = General somatic efferent
GVE = General visceral efferent
SVE = Special visceral efferent

Segmentation of the Hindbrain

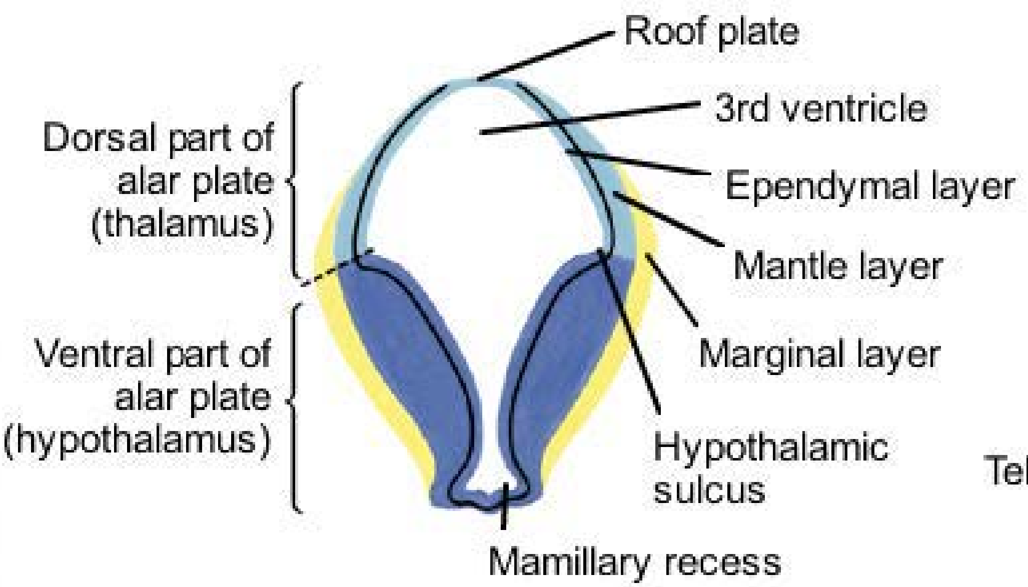


Development of the Forebrain

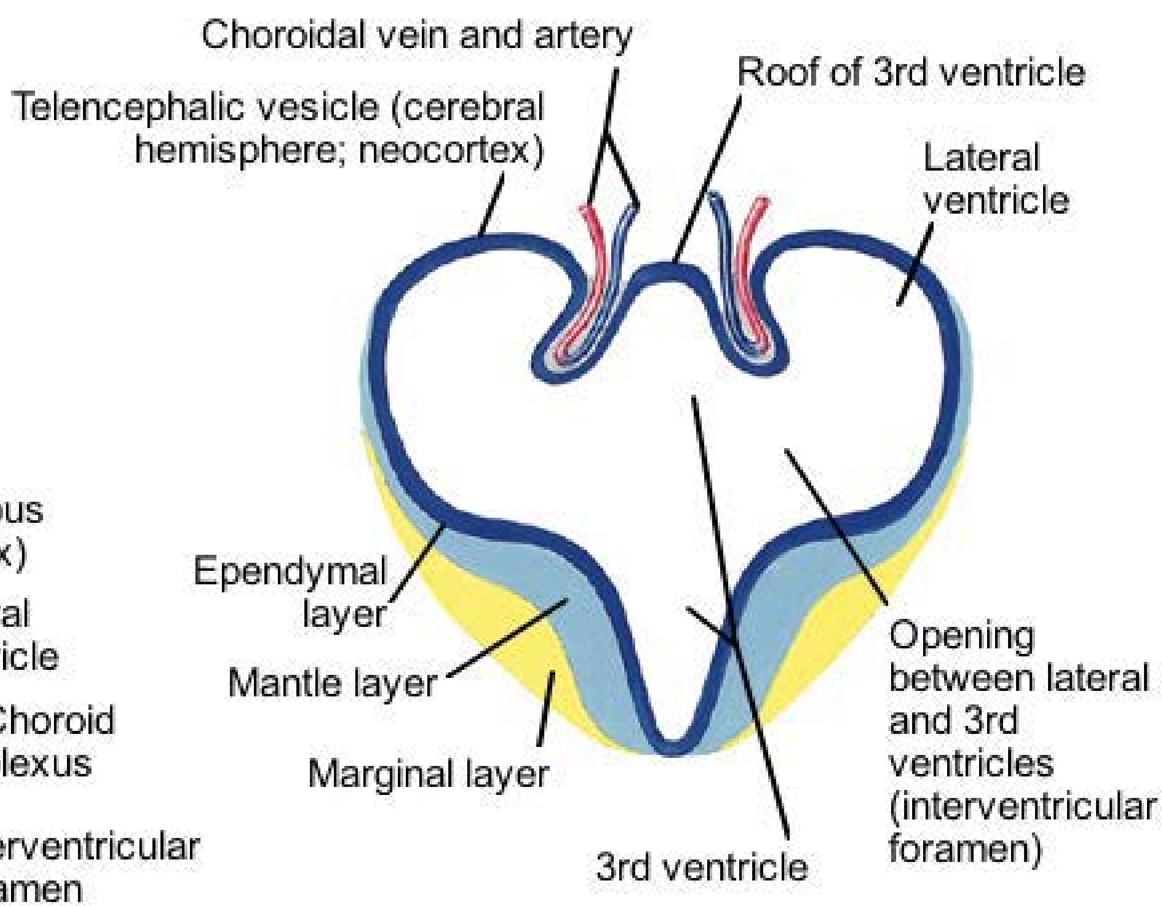


Development of the Forebrain

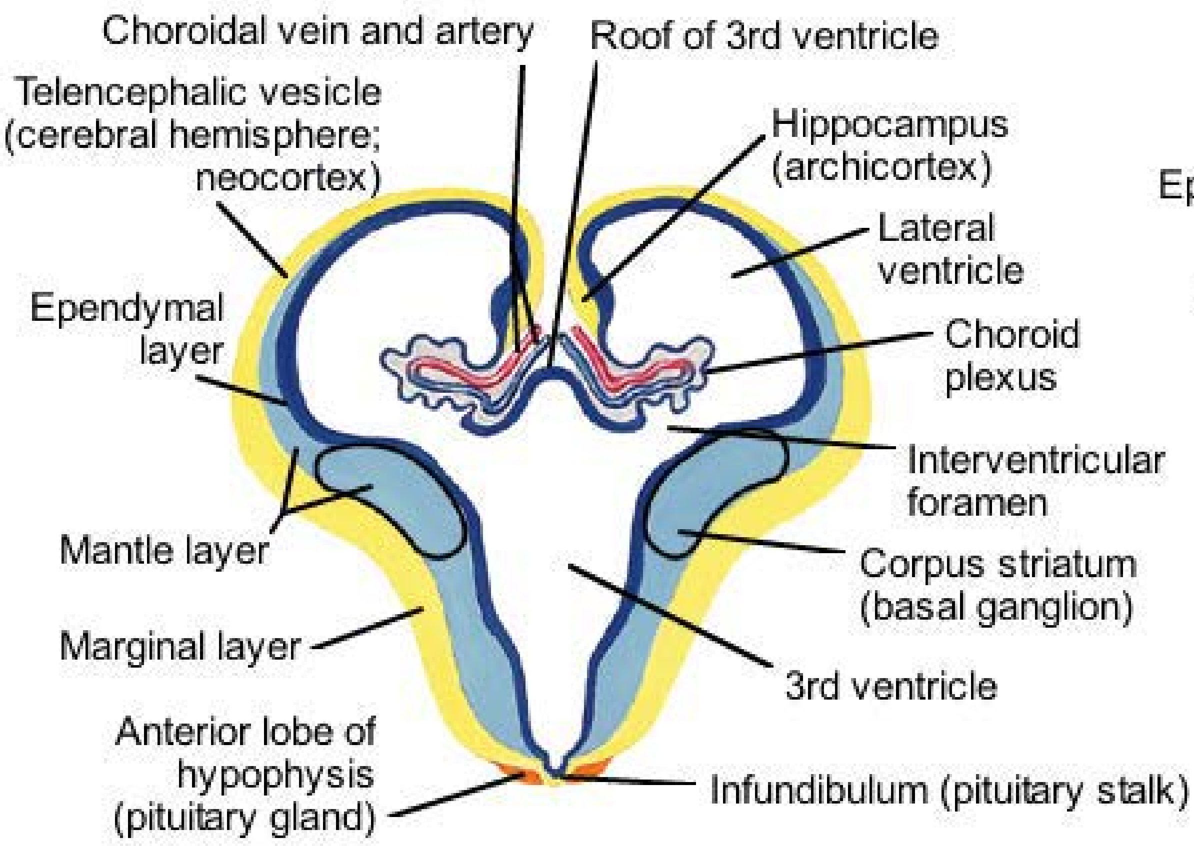
Diencephalon 5 1/2 weeks (transverse section)



Forebrain at 7 weeks (transverse section)

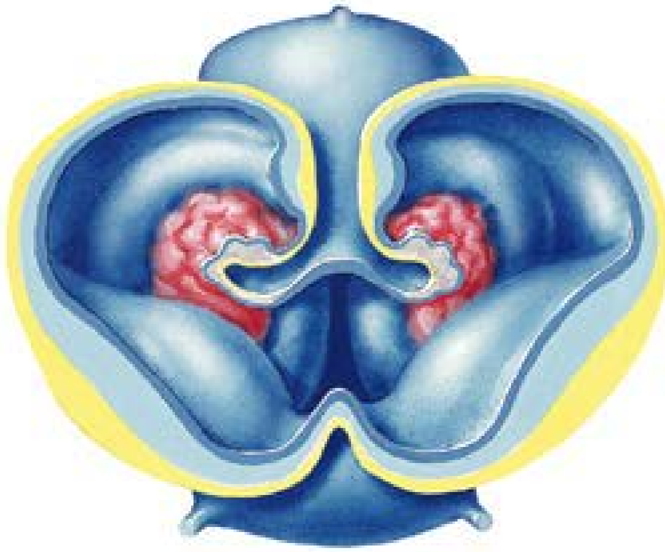


Telencephalon at 7 1/2 weeks (transverse section)

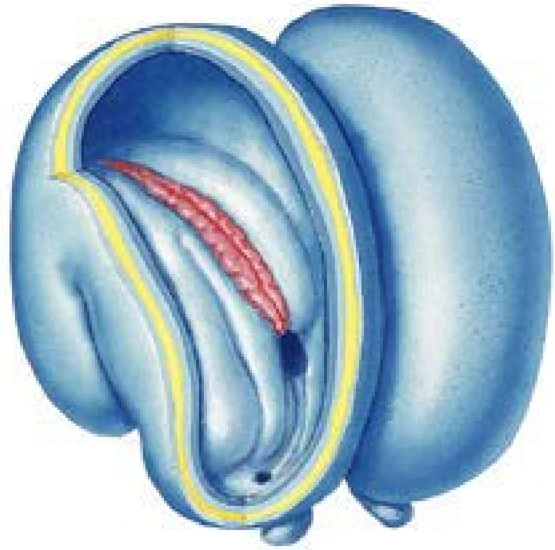


Develoment of the Forebrain

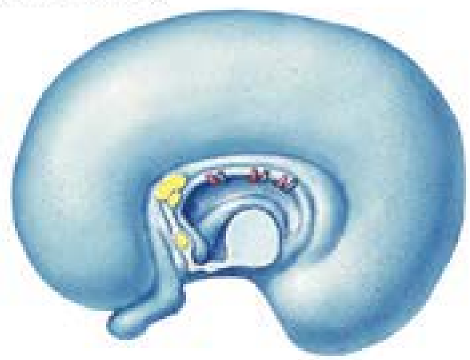
Forebrain at 2 Months
(coronal section; anterior view)



Telencephalon at 2 1/2 months
(right anterior view)

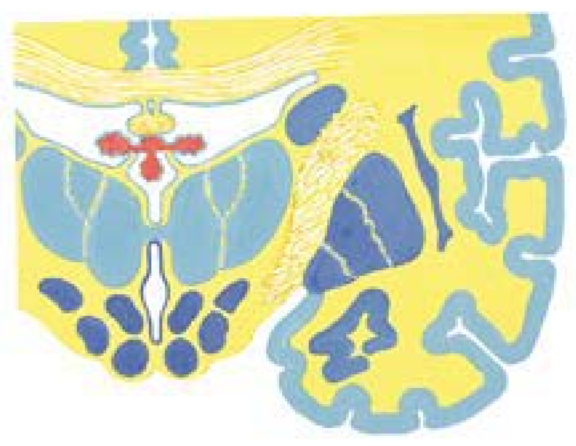


Right cerebral hemisphere at 3 months
(medial aspect)



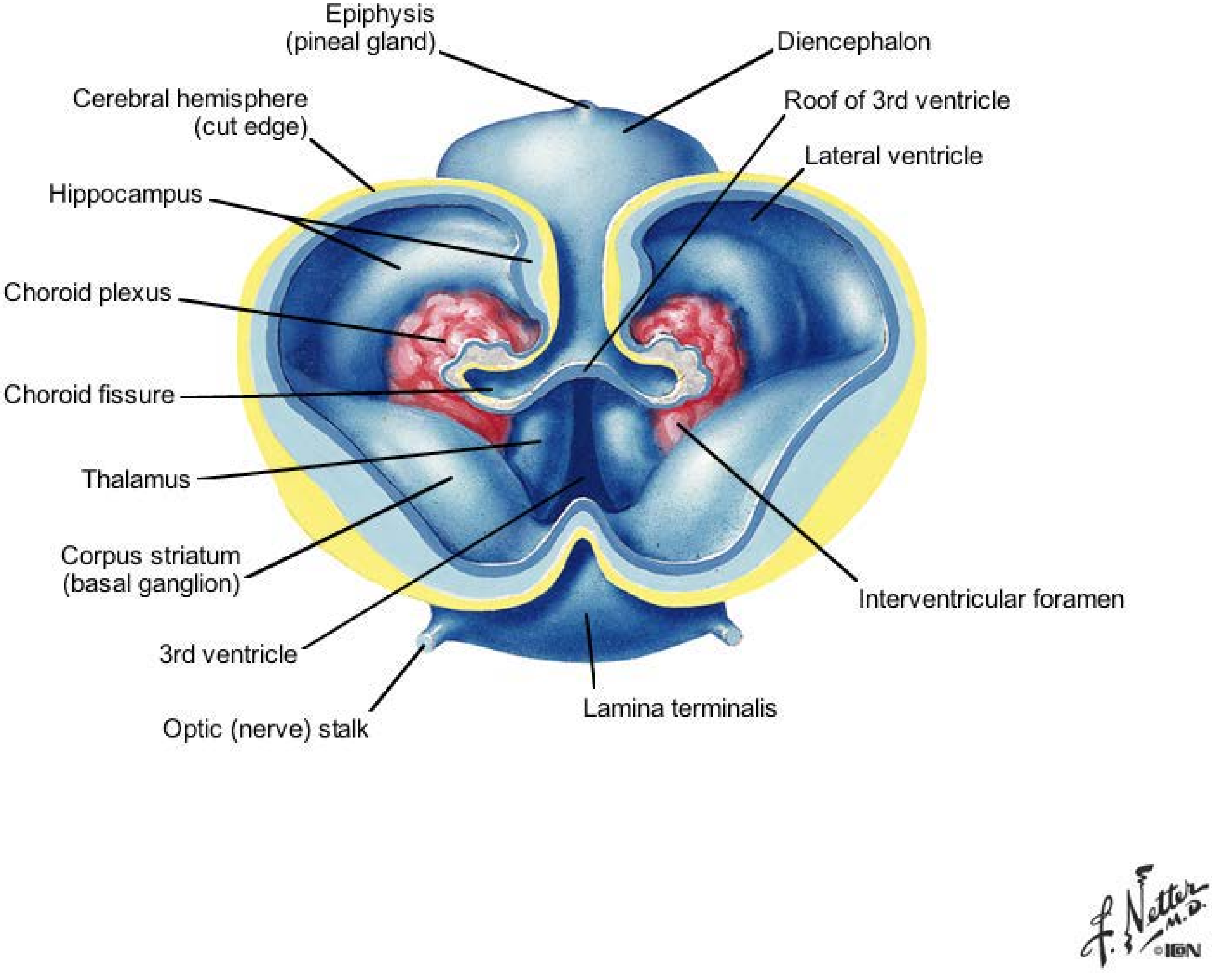
Cerebral hemispheres at 3 months
(coronal section)

Diencephalon and telencephalon
Mature (coronal section)



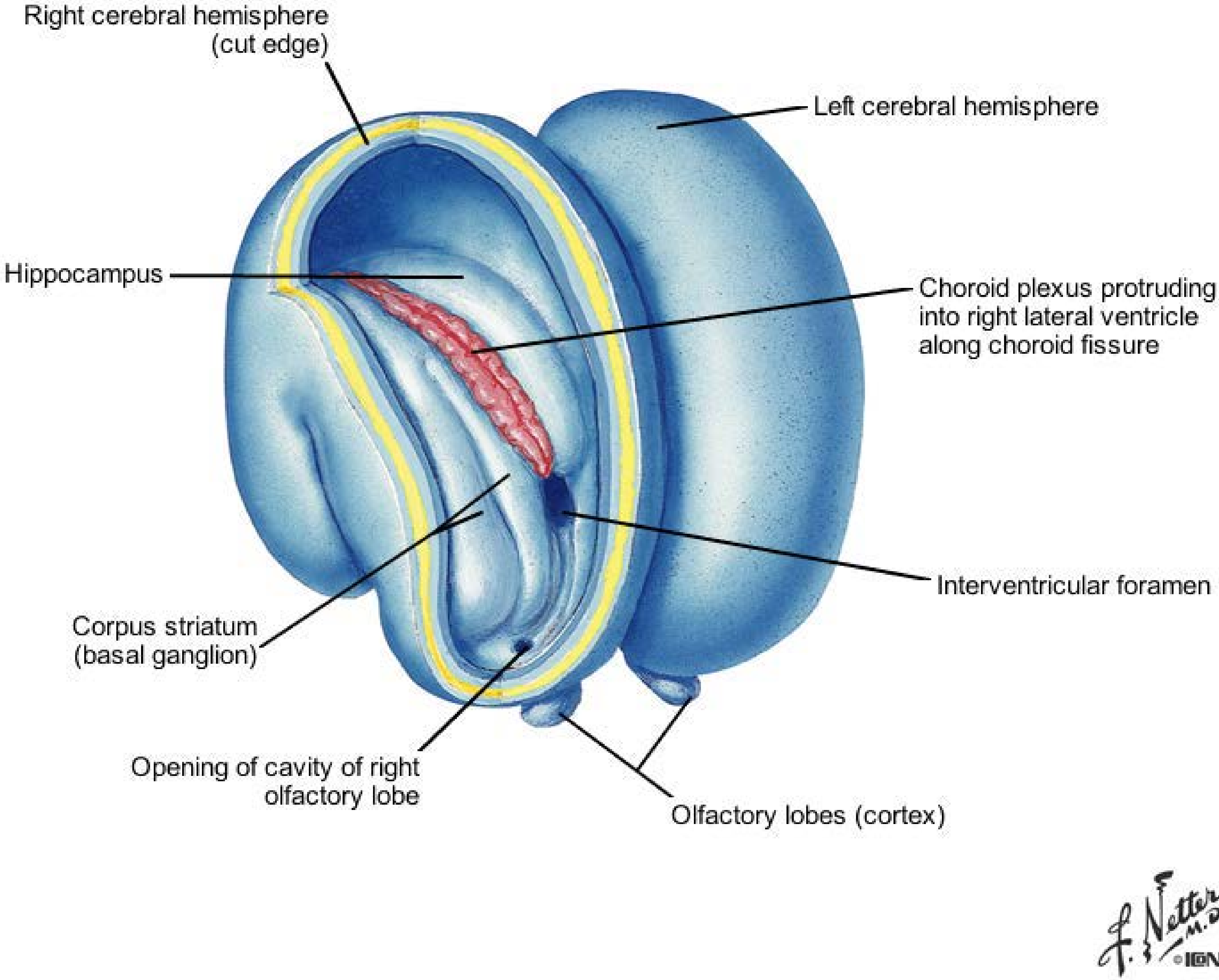
Development of the Forebrain

Forebrain at 2 Months (coronal section; anterior view)



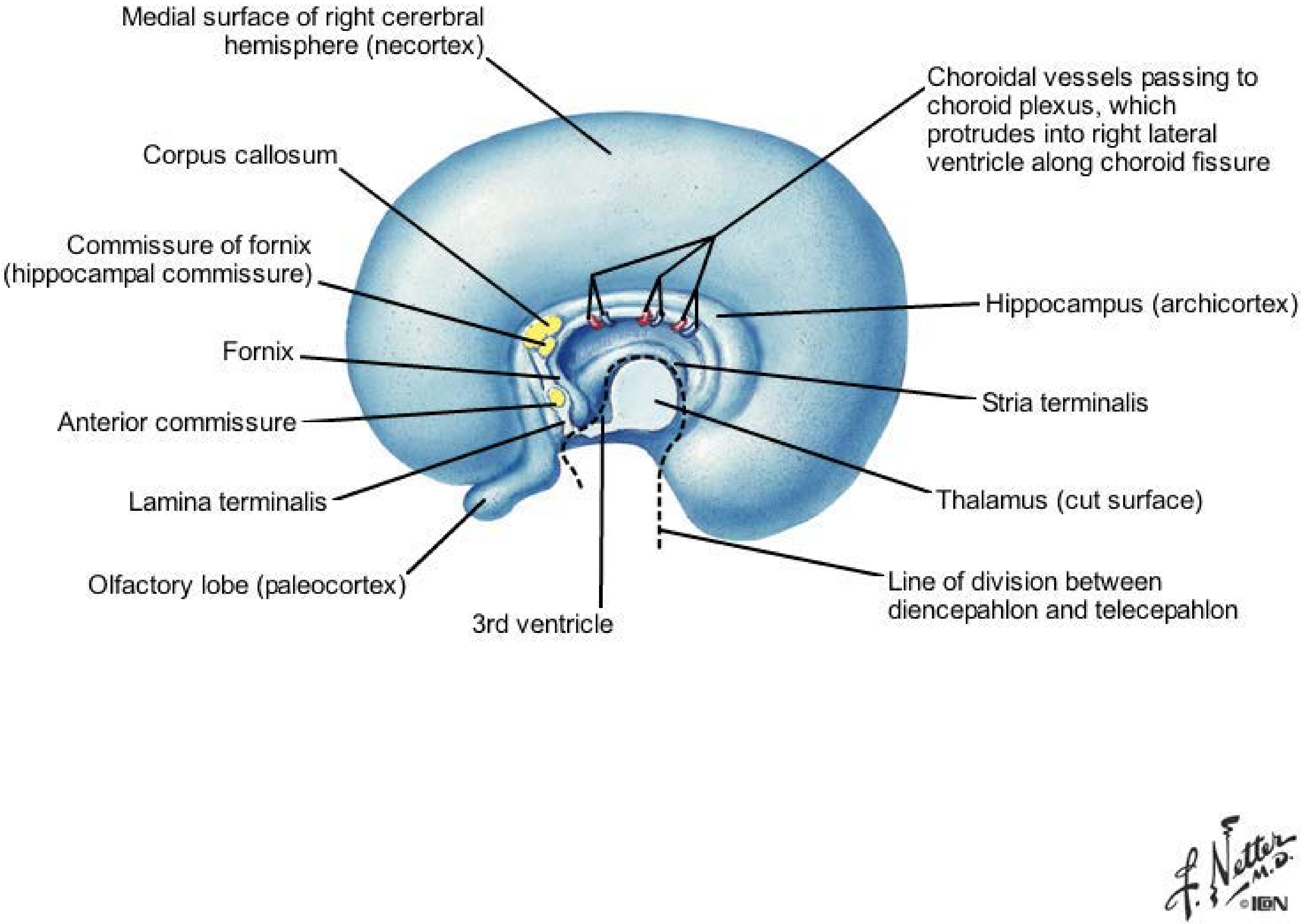
Development of the Forebrain

Telencephalon at 2 1/2 months (right anterior view)



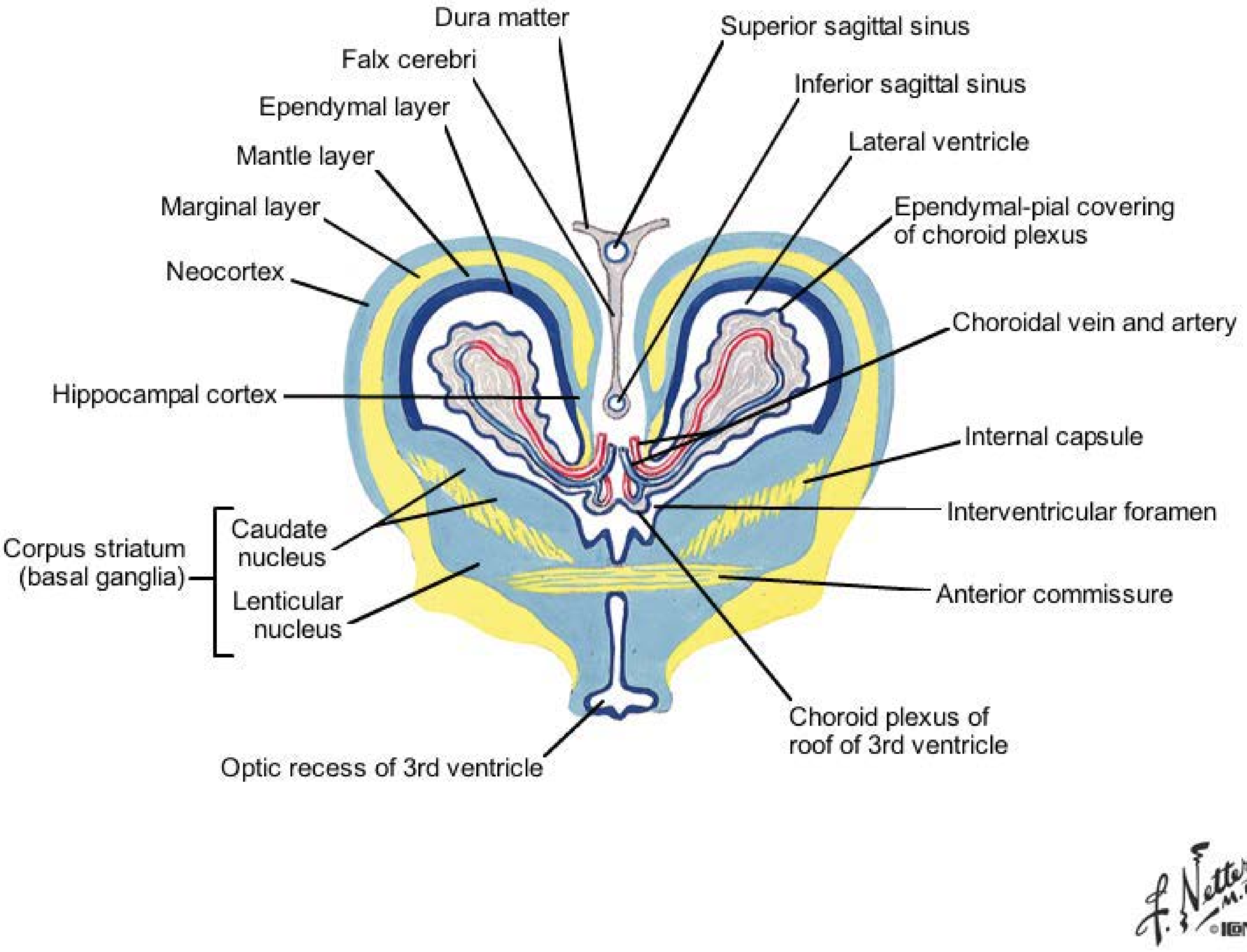
Development of the Forebrain

Right cerebral hemisphere at 3 months (medial aspect)



Development of the Forebrain

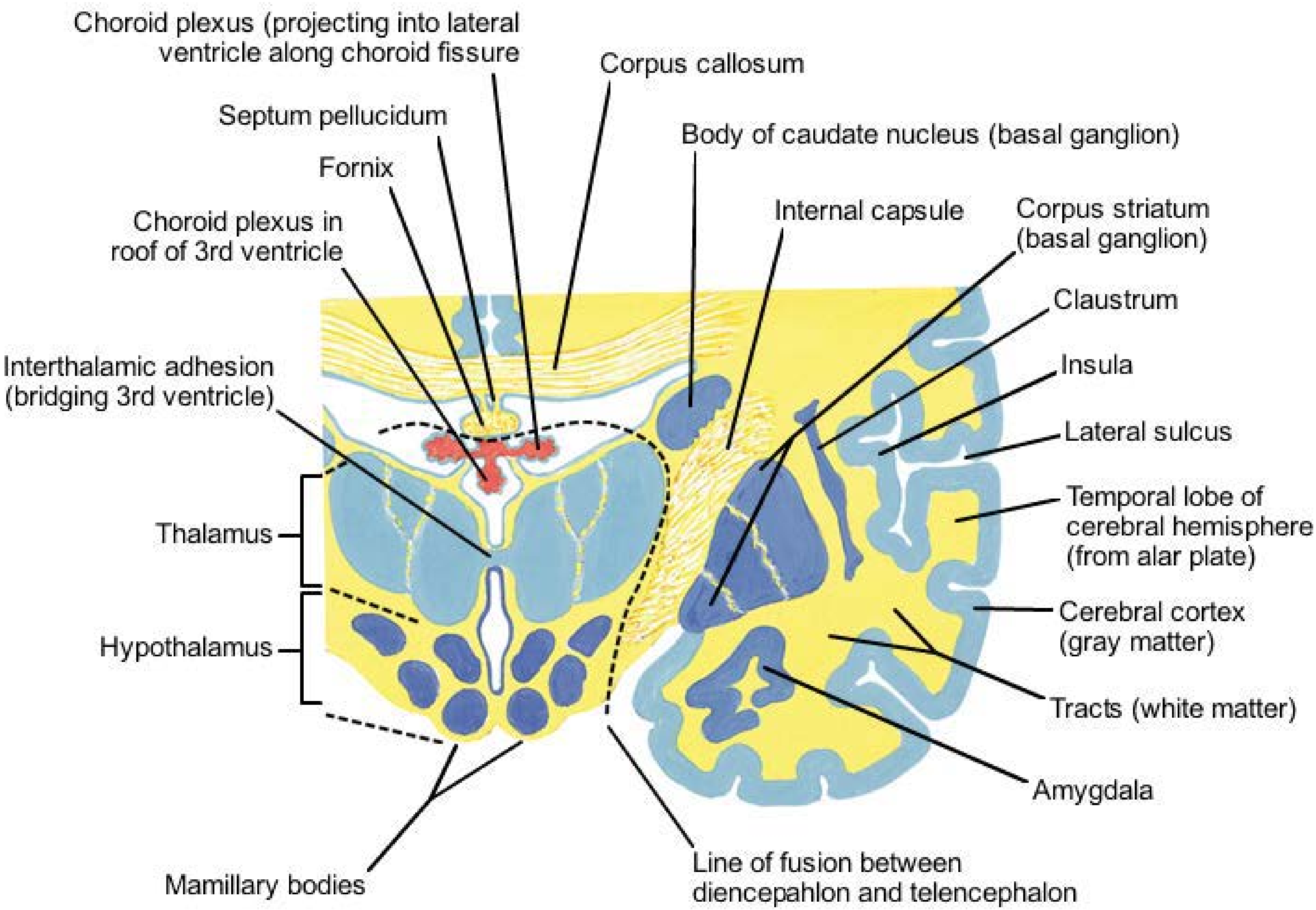
Cerebral hemispheres at 3 months (coronal section)



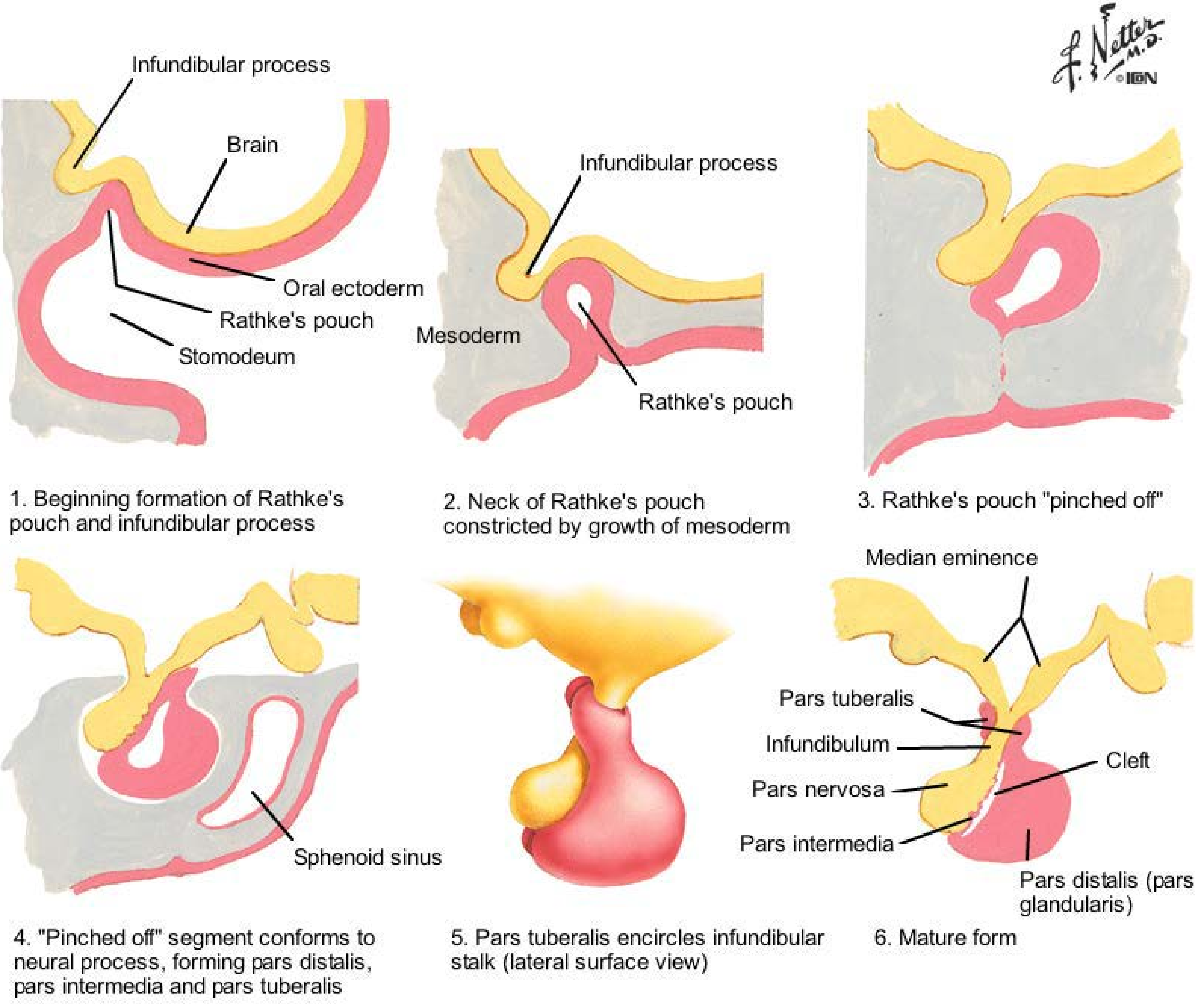
Development of the Forebrain

Diencepahlon and telencepahlon

Mature (coronal section)



Development of the Pituitary Gland



1. Beginning formation of Rathke's pouch and infundibular process

2. Neck of Rathke's pouch constricted by growth of mesoderm

3. Rathke's pouch "pinched off"

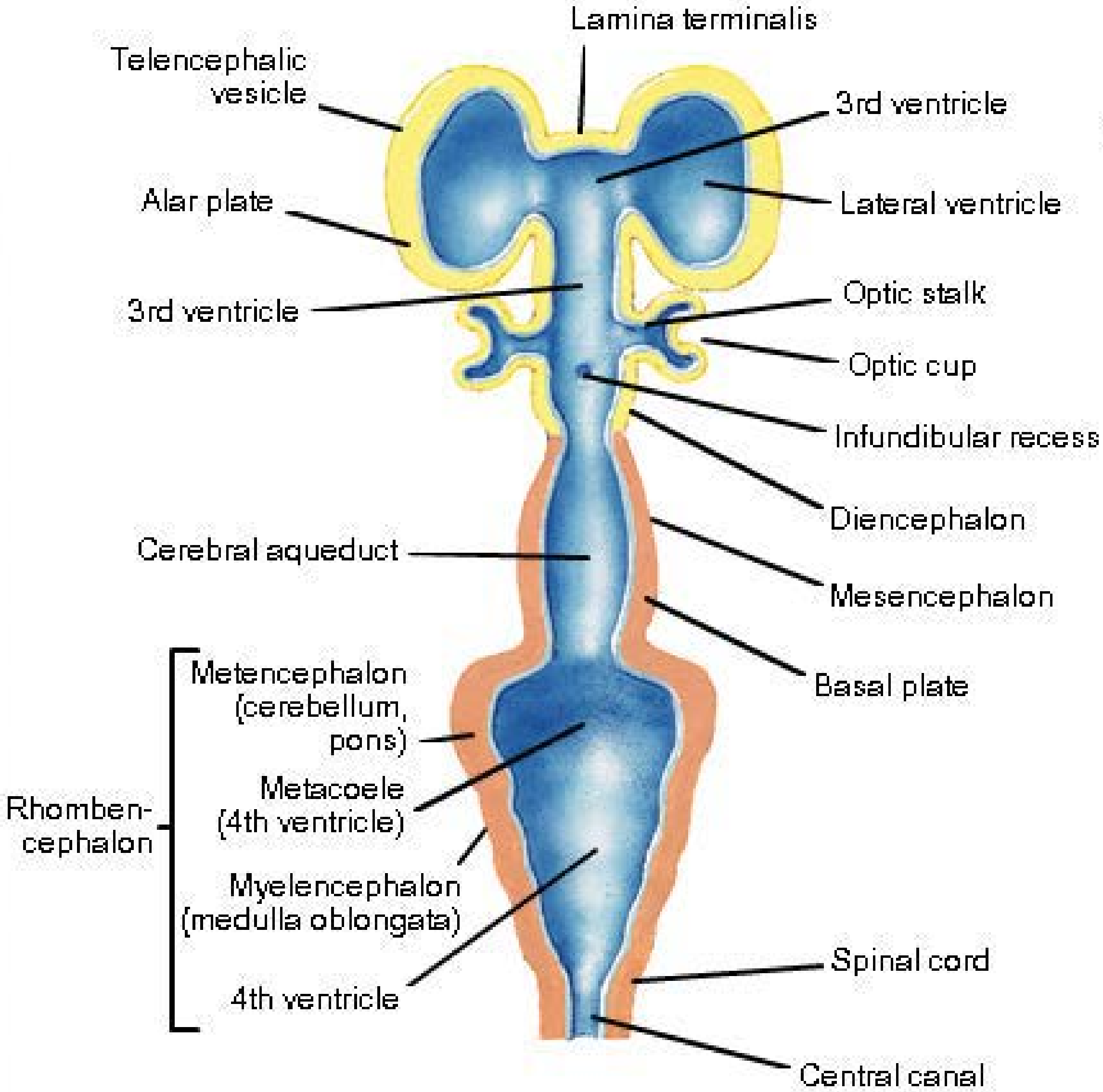
4. "Pinched off" segment conforms to neural process, forming pars distalis, pars intermedia and pars tuberalis

5. Pars tuberalis encircles infundibular stalk (lateral surface view)

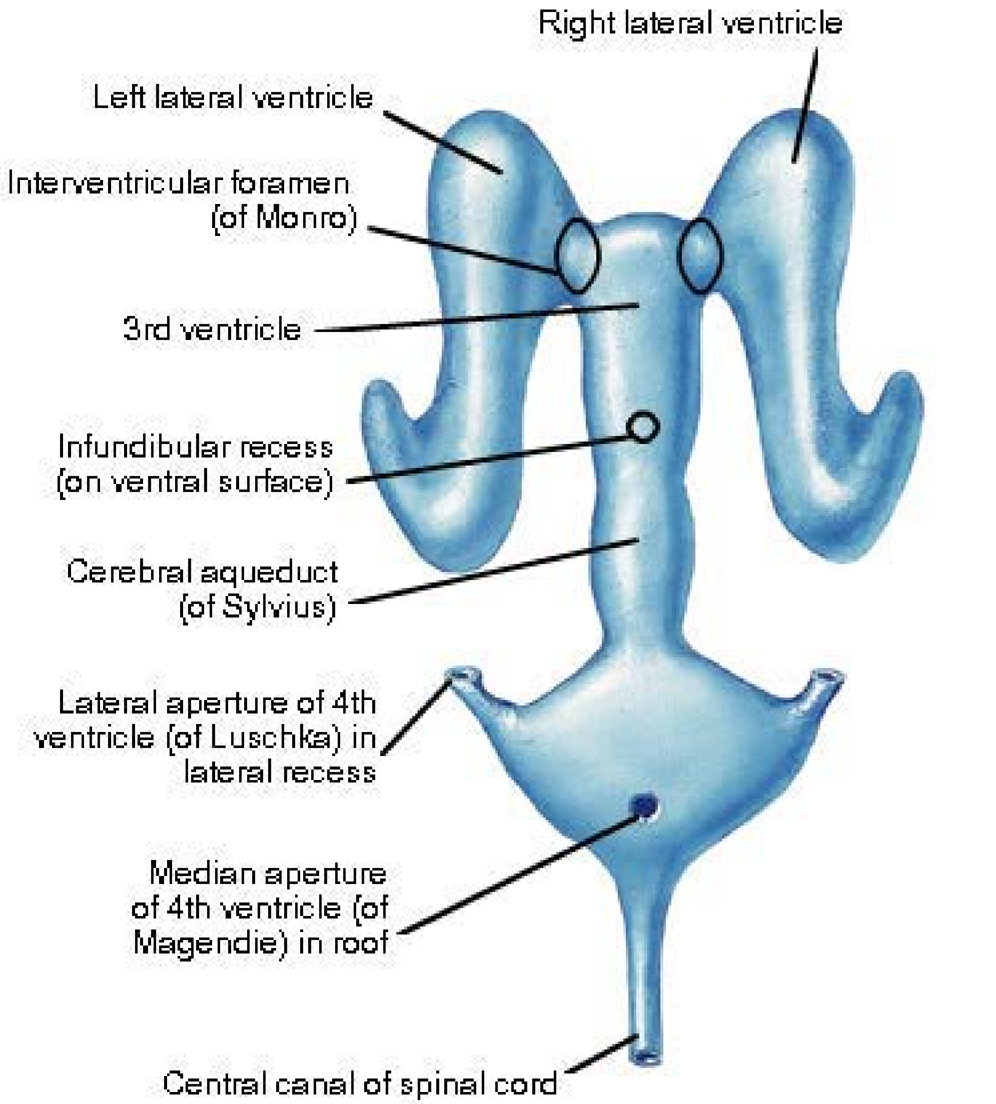
6. Mature form

Development of the Ventricles

Frontal section (ventral to sulcus limitans) at 36 days



Ependymal lining of cavities of brain at 3 months



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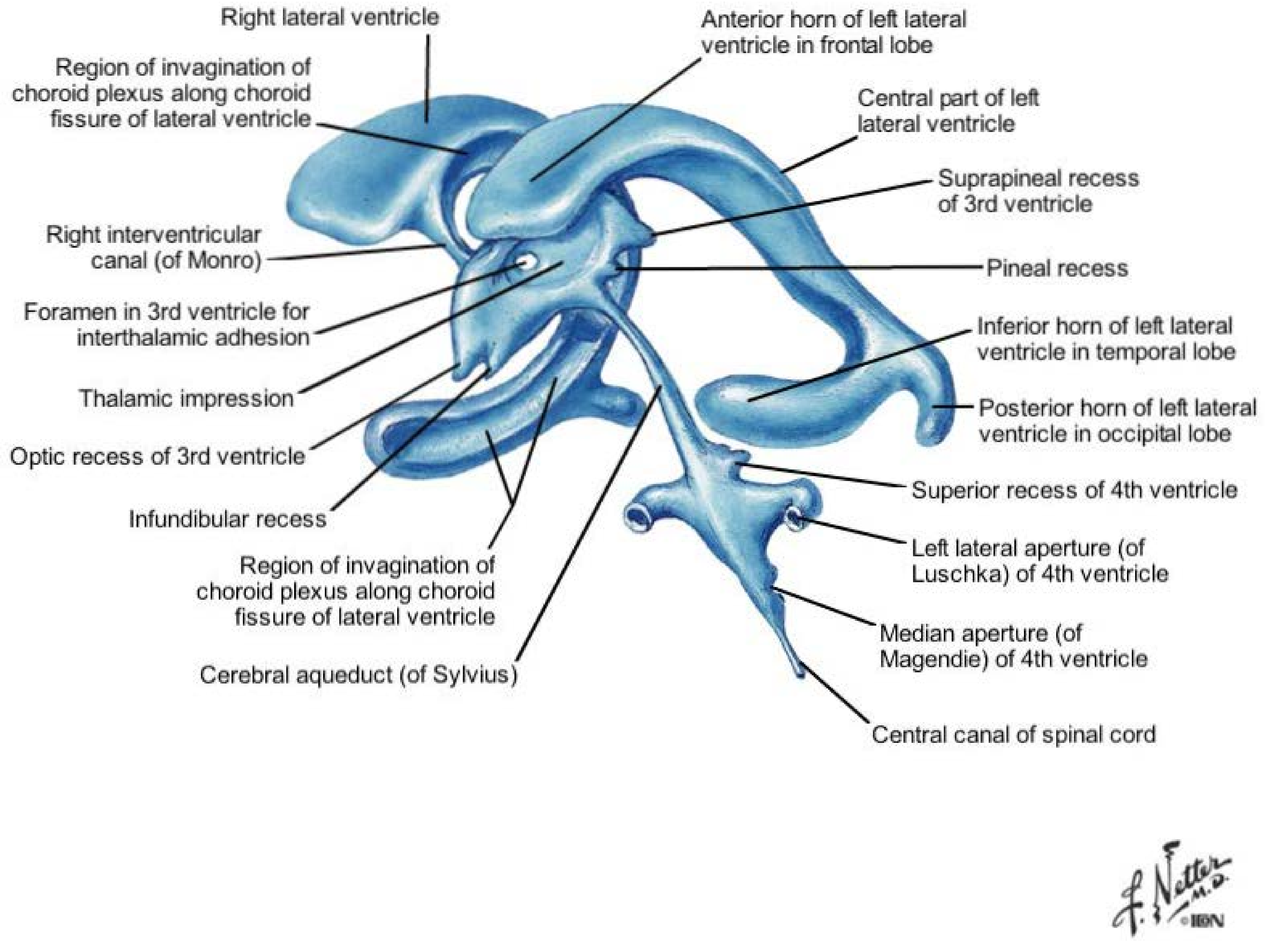
Development of the Ventricles

Ependymal lining of cavities of brain at 9 months (birth)



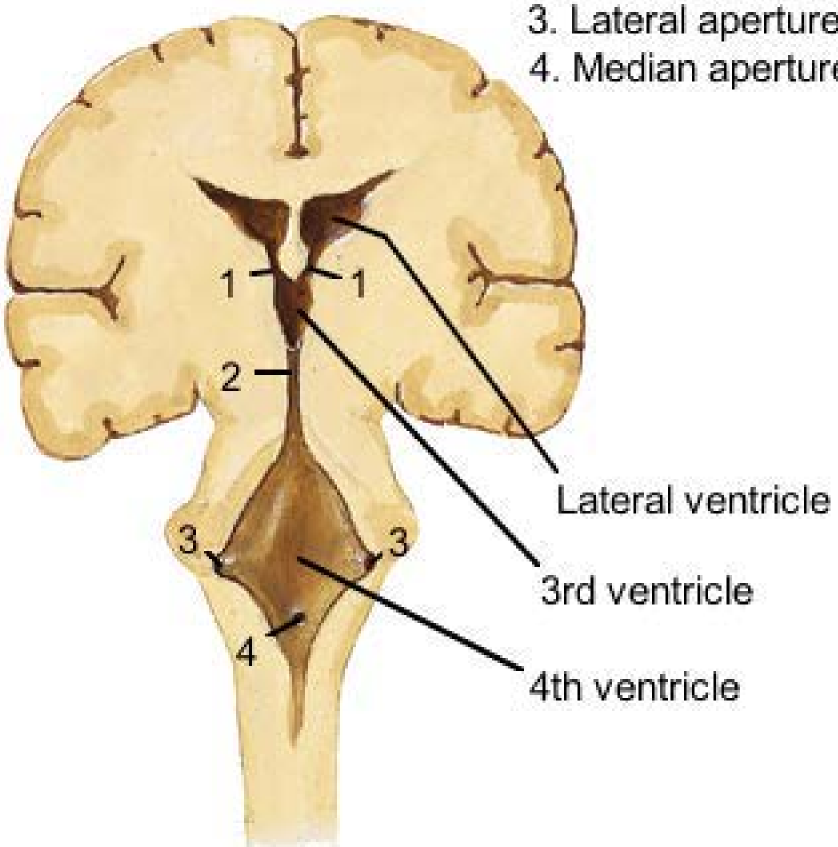
Congenital Ventricular Defects

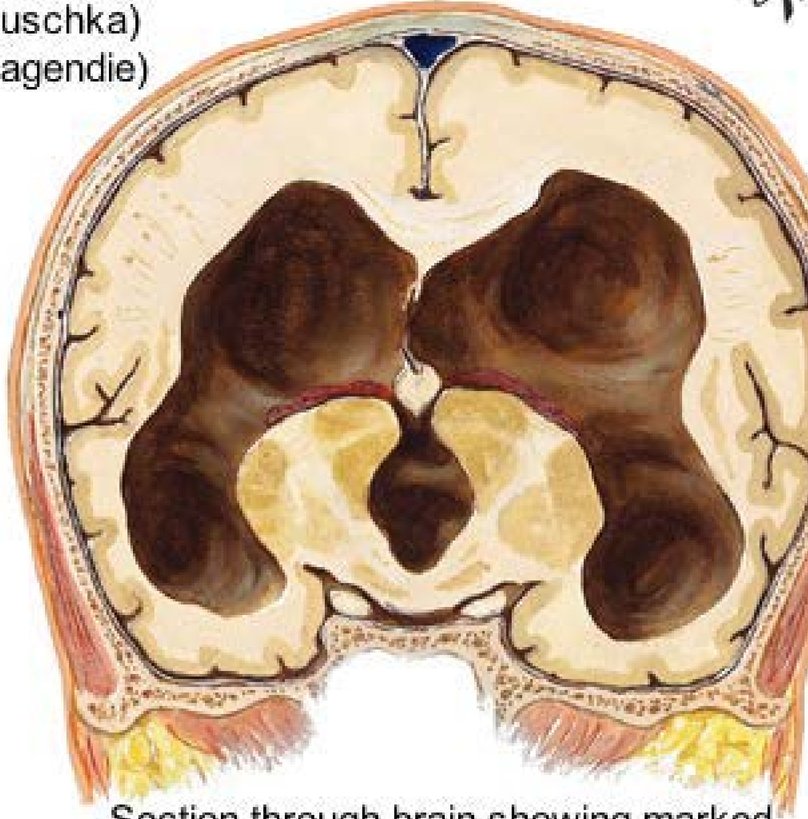
Hydrocephalus

Clinical appearance in advanced hydrocephalus

Potential lesion sites in obstructive hydrocephalus

1. Interventricular foramina (of Monro)
2. Cerebral aqueduct (of Sylvius)
3. Lateral apertures (of Luschka)
4. Median aperture (of Magendie)





Section through brain showing marked dilation of lateral and 3rd ventricles

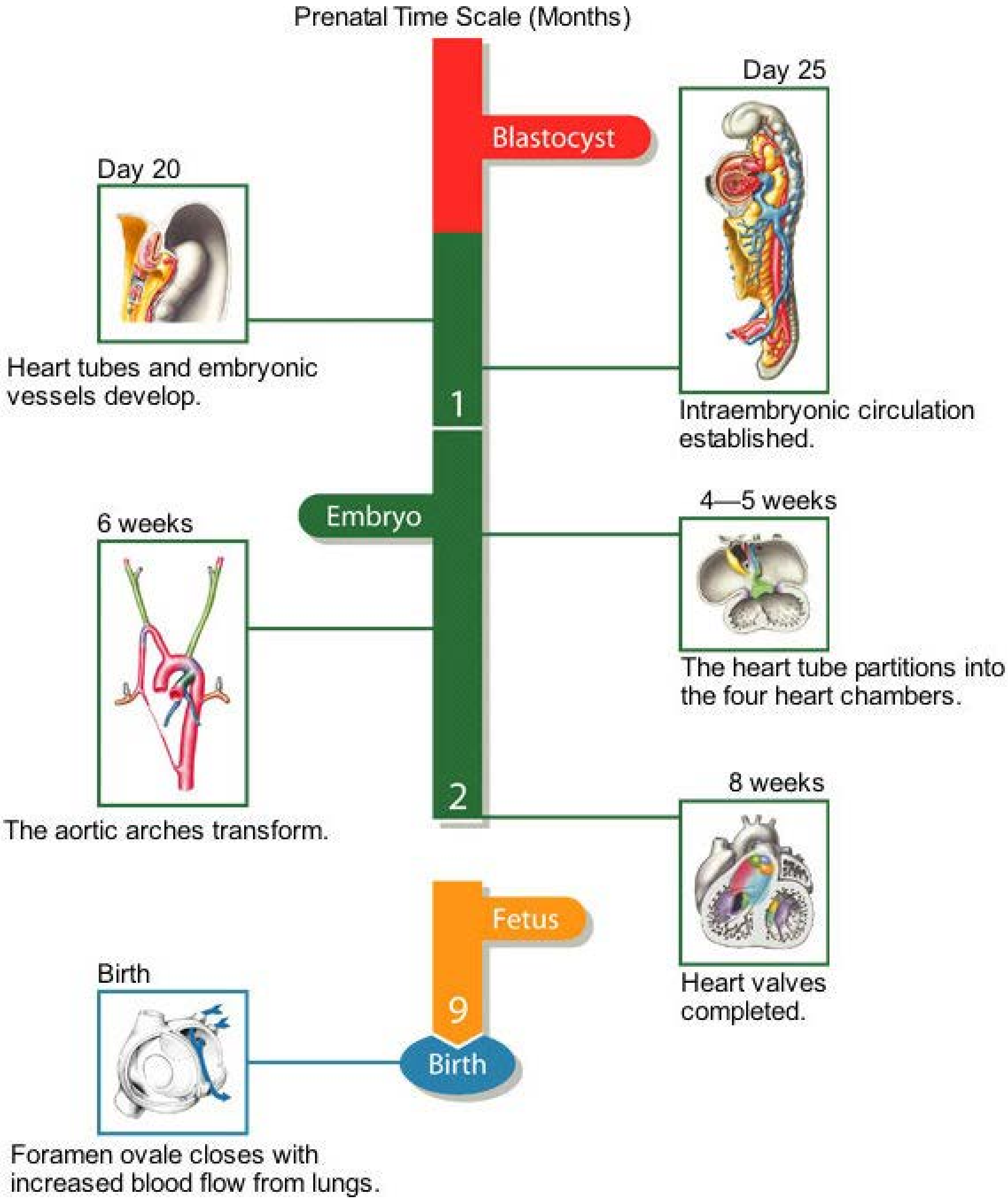
Adult Derivatives of the Forebrain, MidBrain, and Hindbrain

Forebrain	Telencephalon	Cerebral hemispheres (neocortex) Olfactory cortex (paleocortex) Hippocampus (archicortex) Basal ganglia/corpus striatum Lateral and 3rd ventricles	Nerves: Olfactory (I)
	Diencephalon	Optic cup/nerves Thalamus Hypothalamus Mammillary bodies Part of 3rd ventricle	Optic (II)
Midbrain	Mesencephalon	Tectum (superior, inferior colliculi) Cerebral aqueduct Red nucleus Substantia nigra Crus cerebelli	Oculomotor (III) Trochlear (IV)
Hindbrain	Metencephalon	Pons Cerebellum	Trigeminal (V) Abducens(VI) Facial (VII) Acoustic (VIII) Glossopharyngeal (IX) Vagus (X) Hypoglossal (XI)
	Myelencephalon	Medulla oblongata	

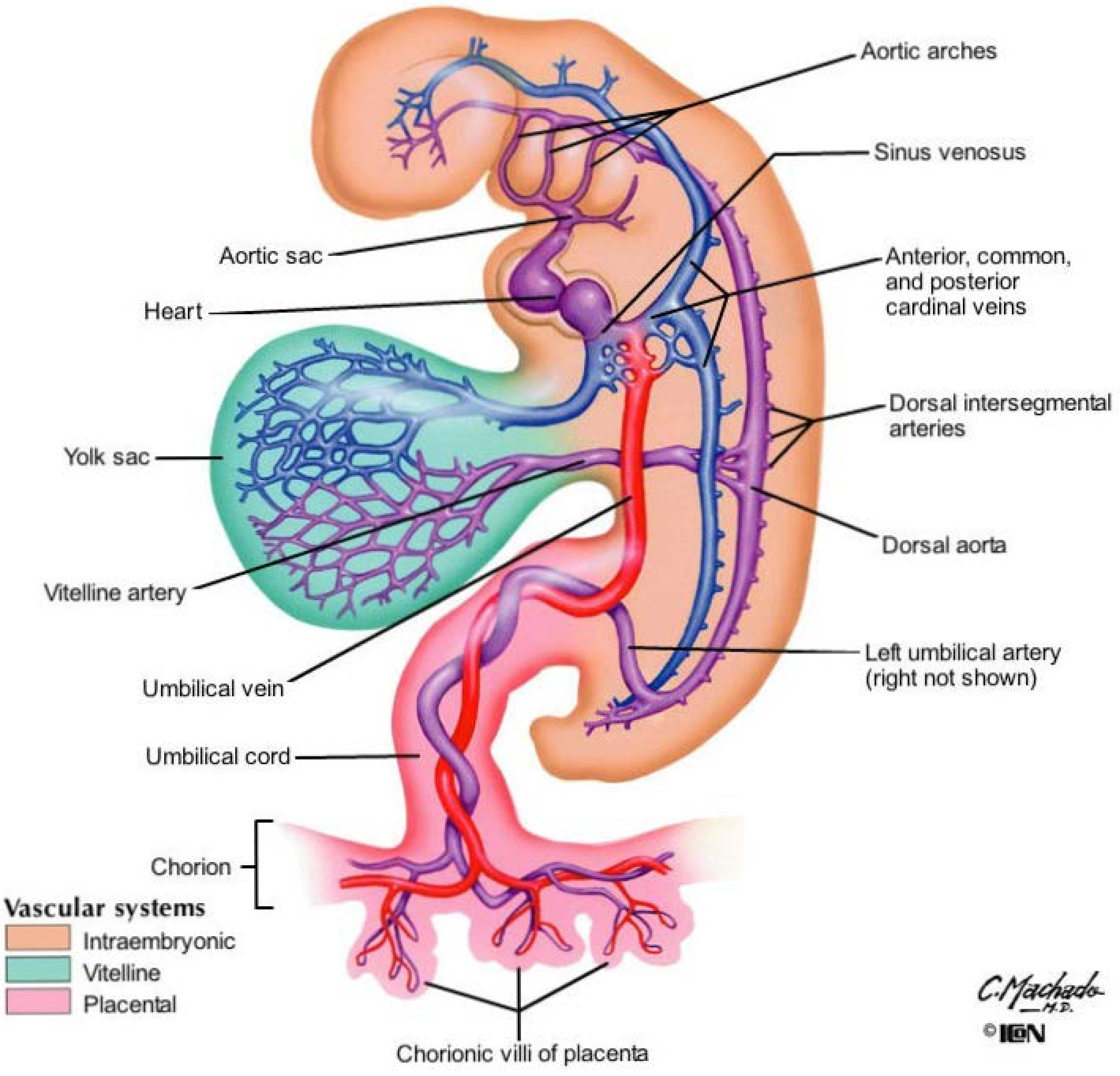
Pituitary Hormones

From the Anterior Lobe (Pars Distalis)		From the Posterior Lobe (Pars Nervosa)
Follicle-stimulating hormone (FSH)	Thyroid-stimulating hormone (TSH)	Vasopressin
Luteinizing hormone (LH)	Adrenocorticotropic hormone (ACTH)	Oxytocin
Prolactin	Growth hormone (GH)	

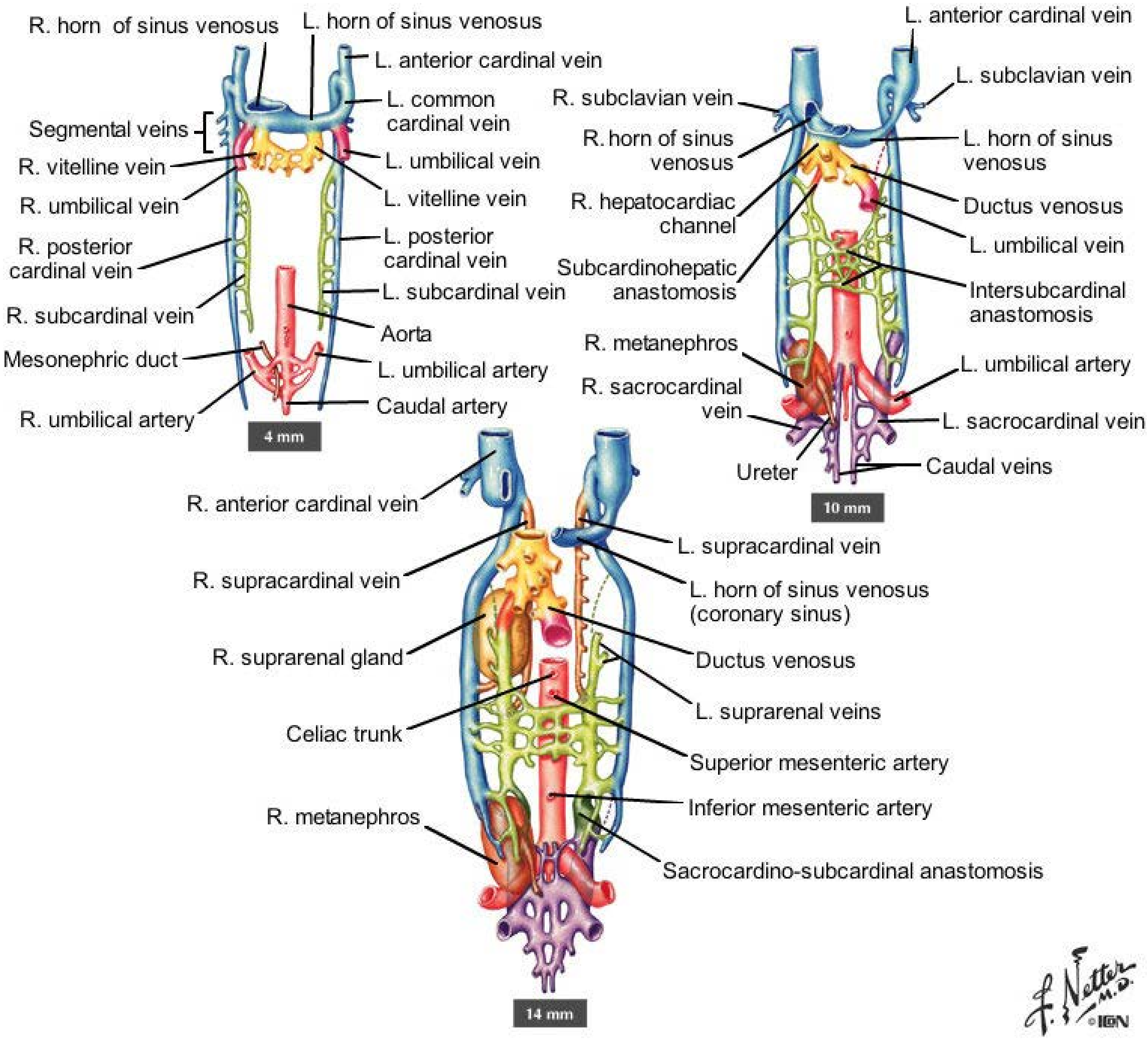
THE CARDIOVASCULAR SYSTEM
TIMELINE



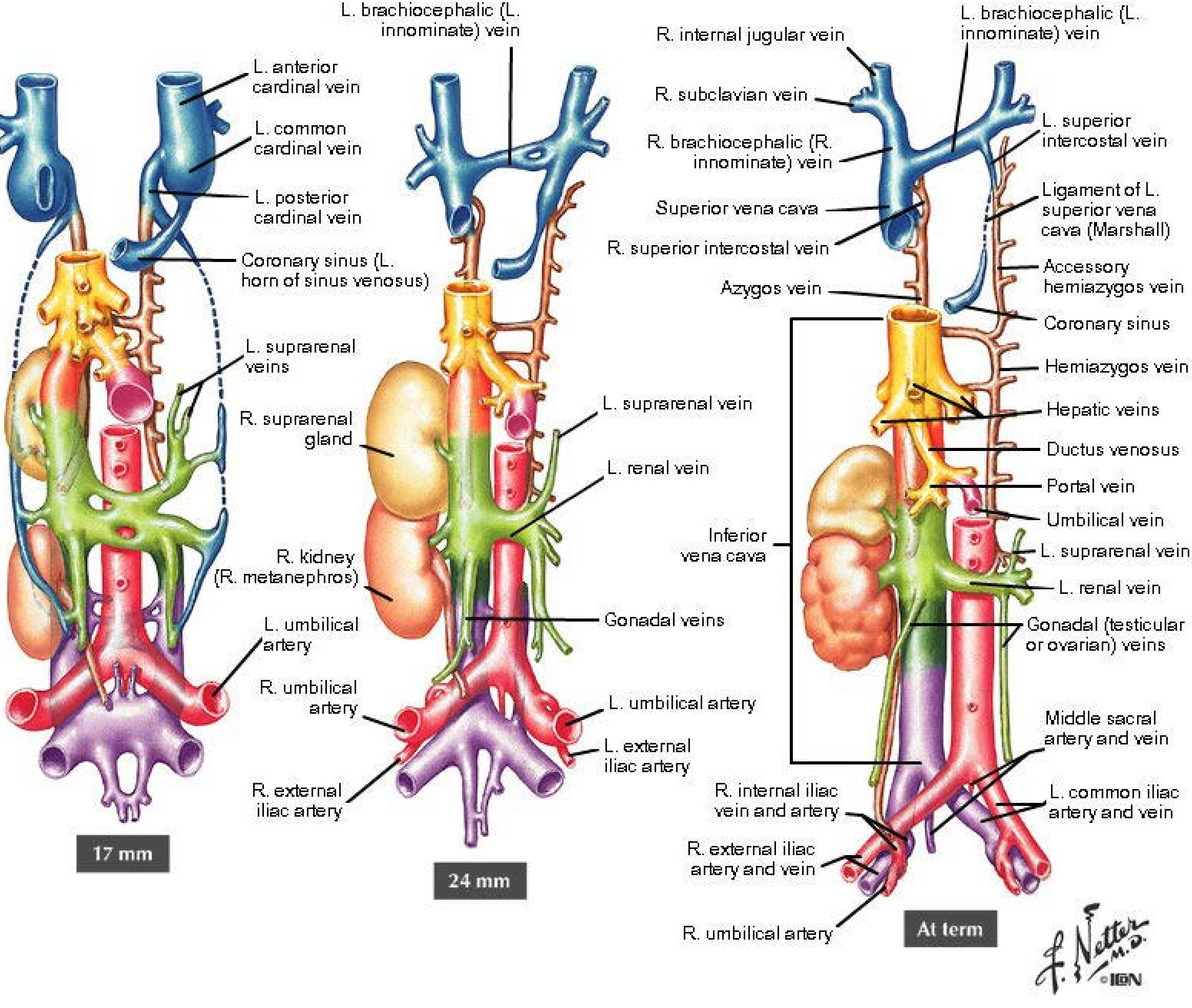
Early Vascular Systems



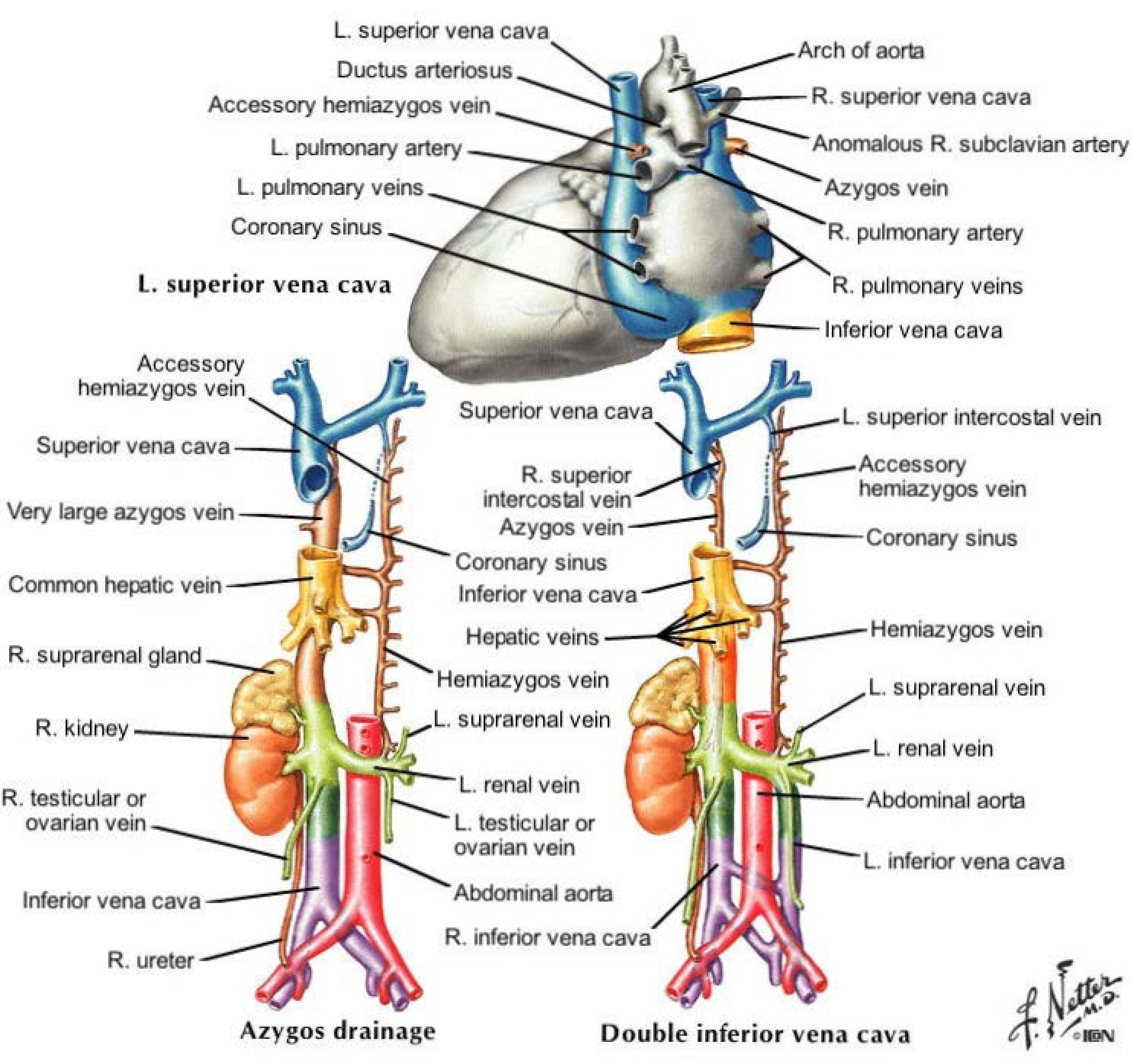
Vein Development



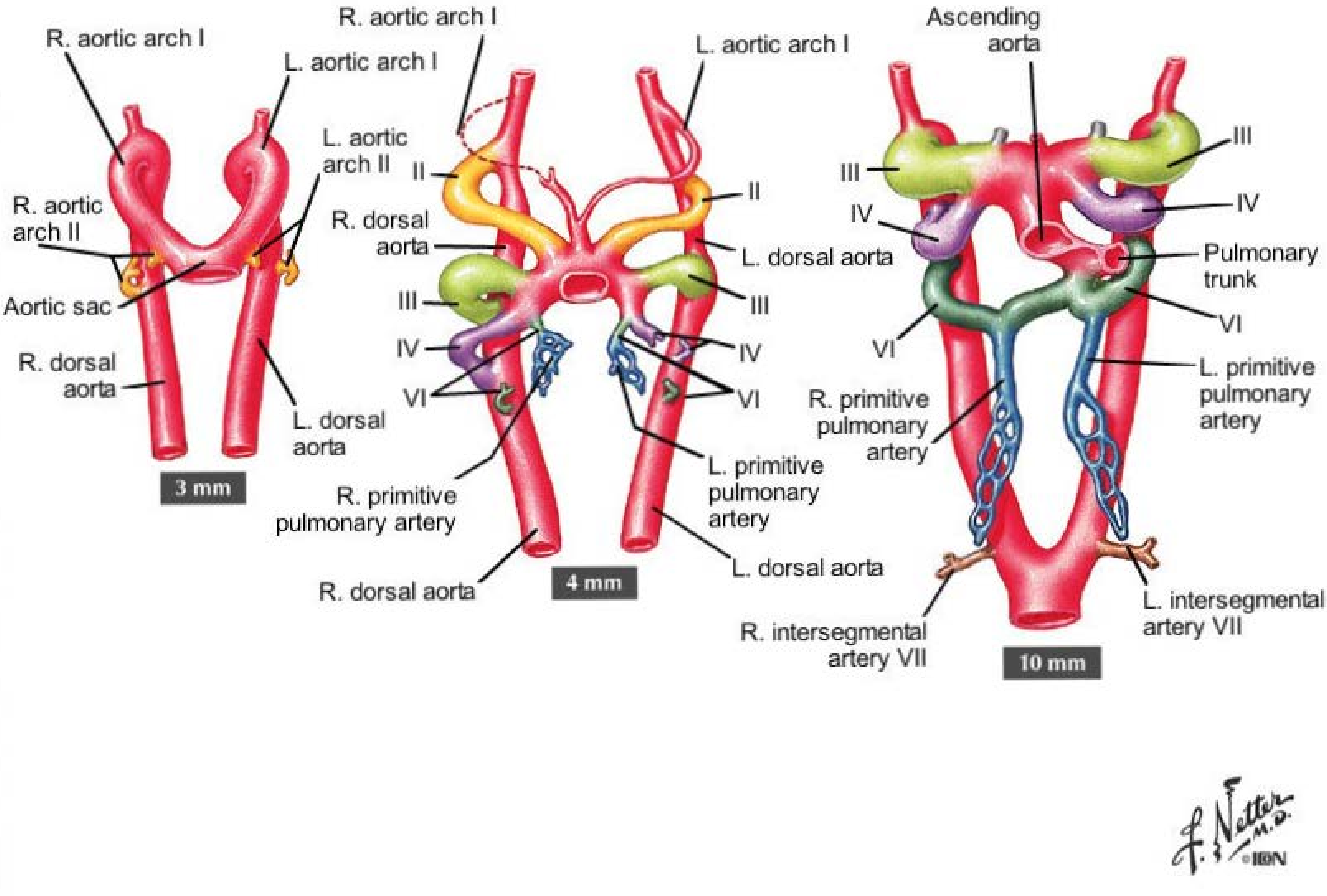
Vein Development



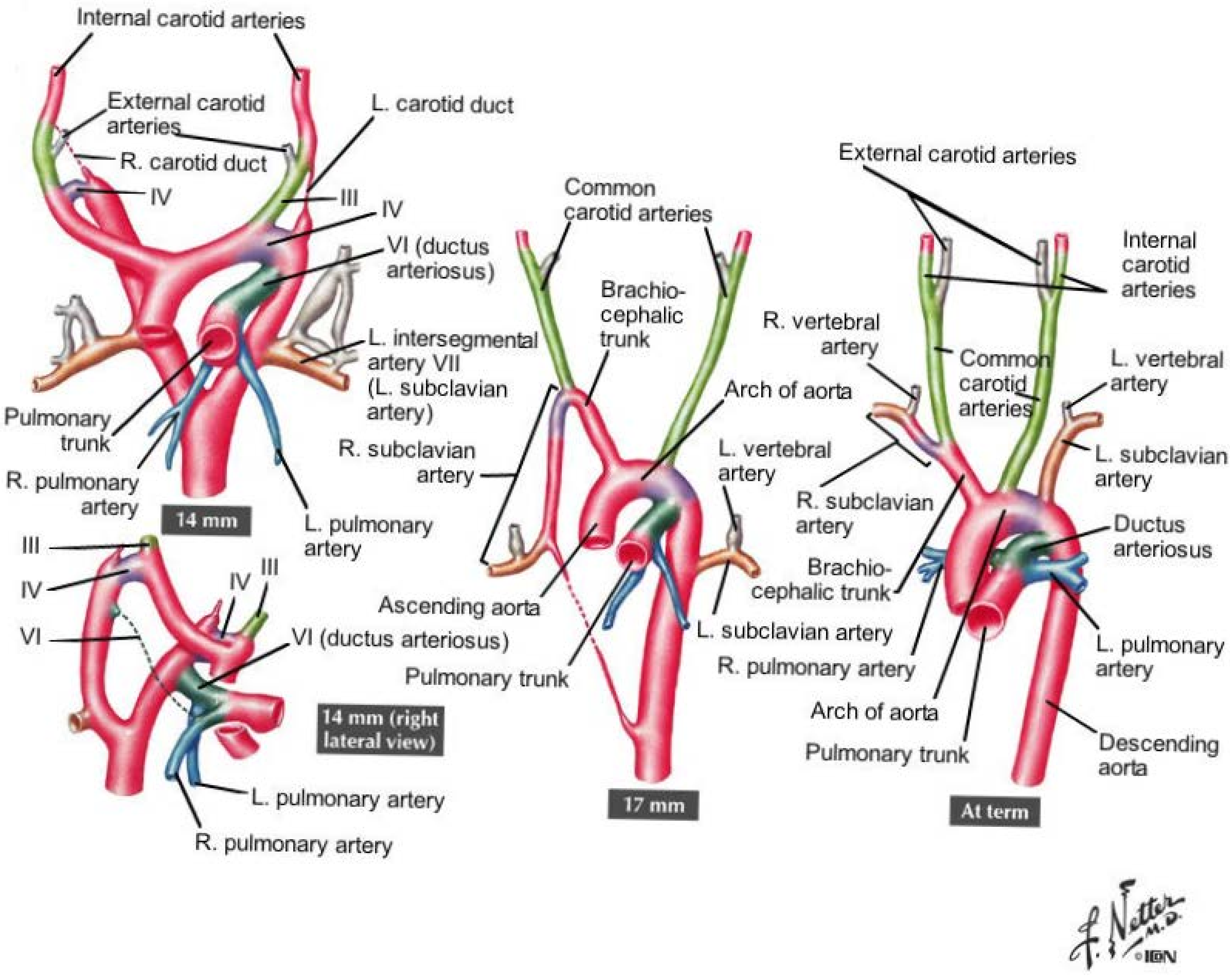
Vein Anomalies



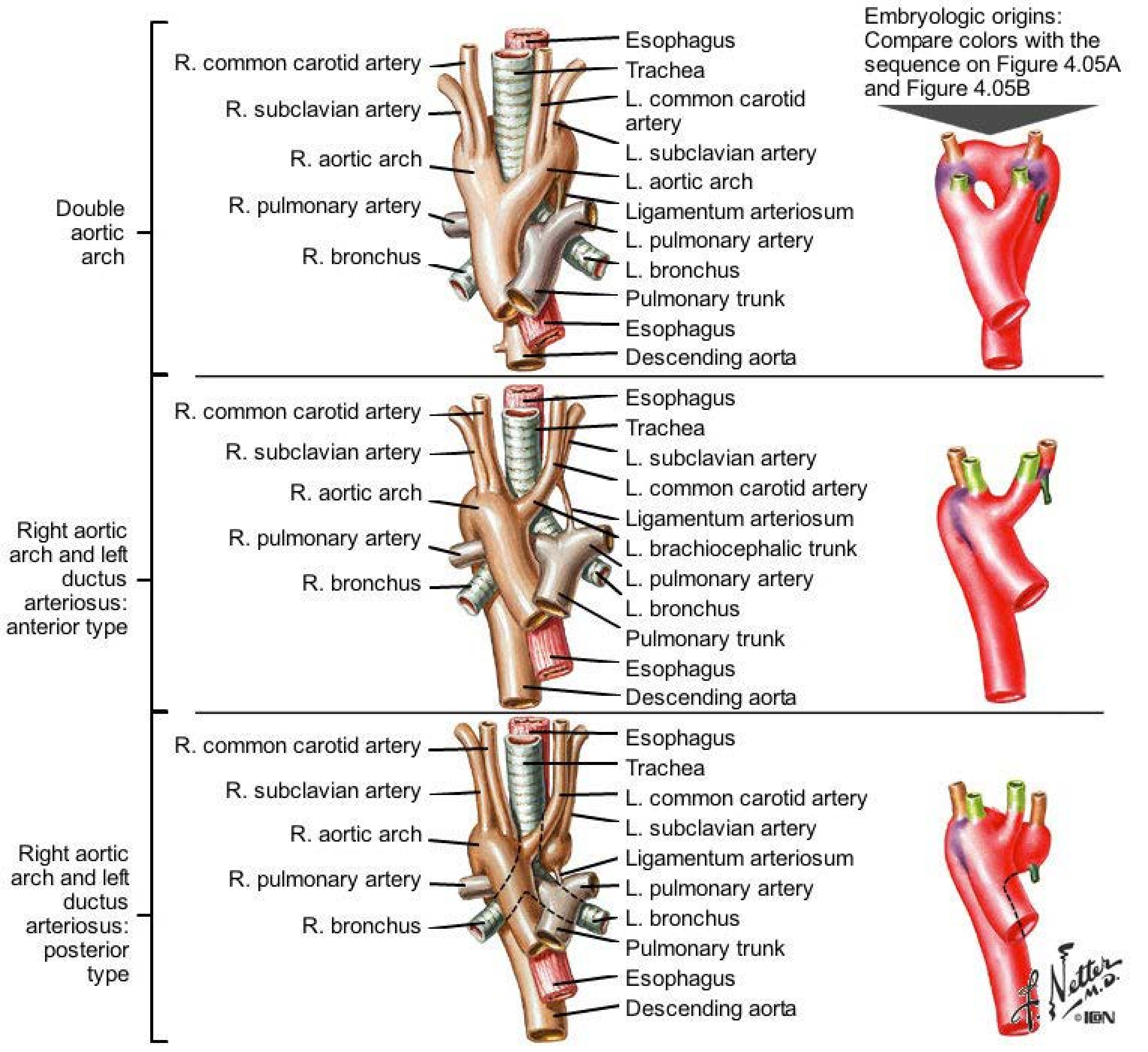
Aortic Arch Arteries



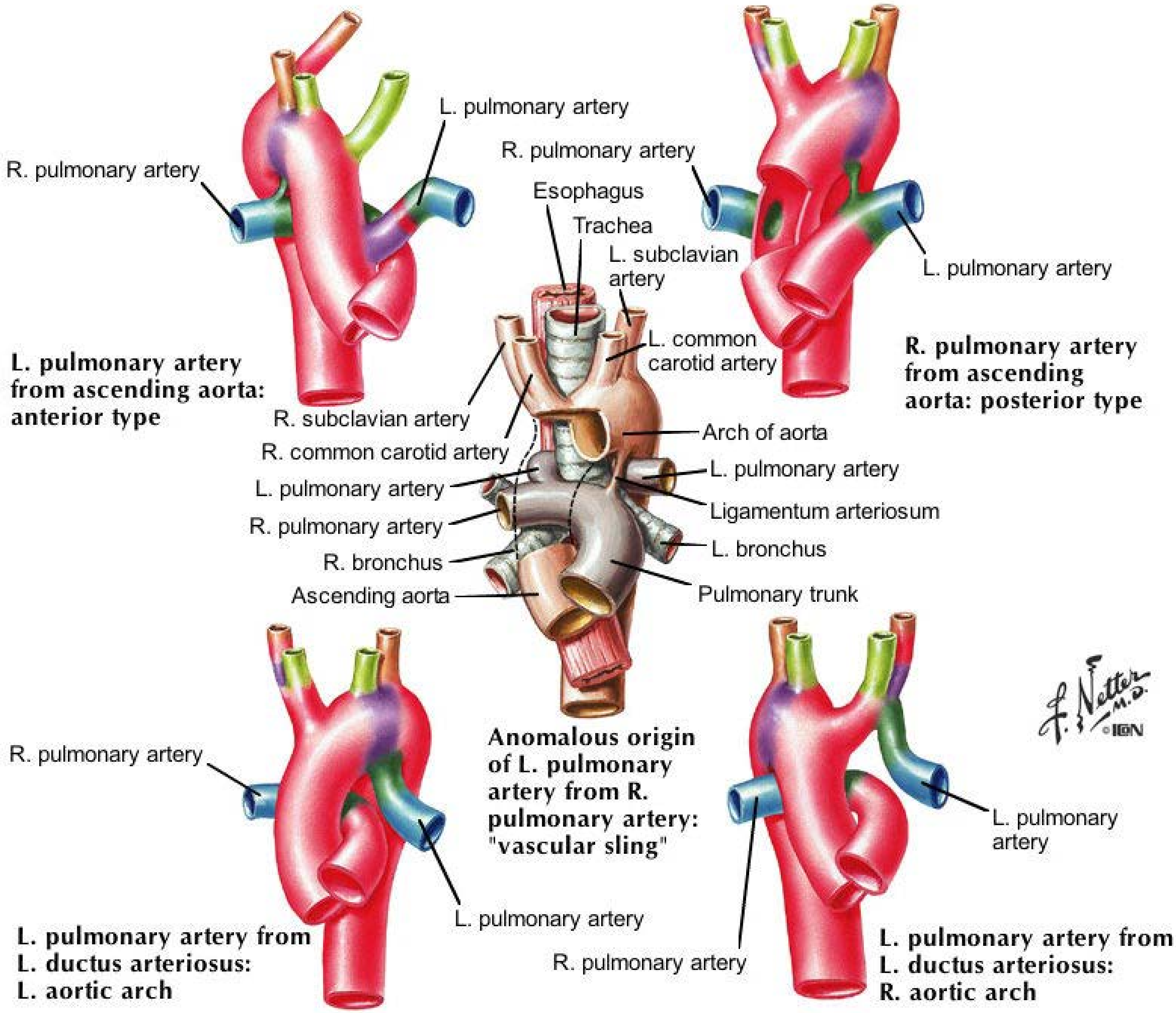
Aortic Arch Arteries



Artery Anomalies

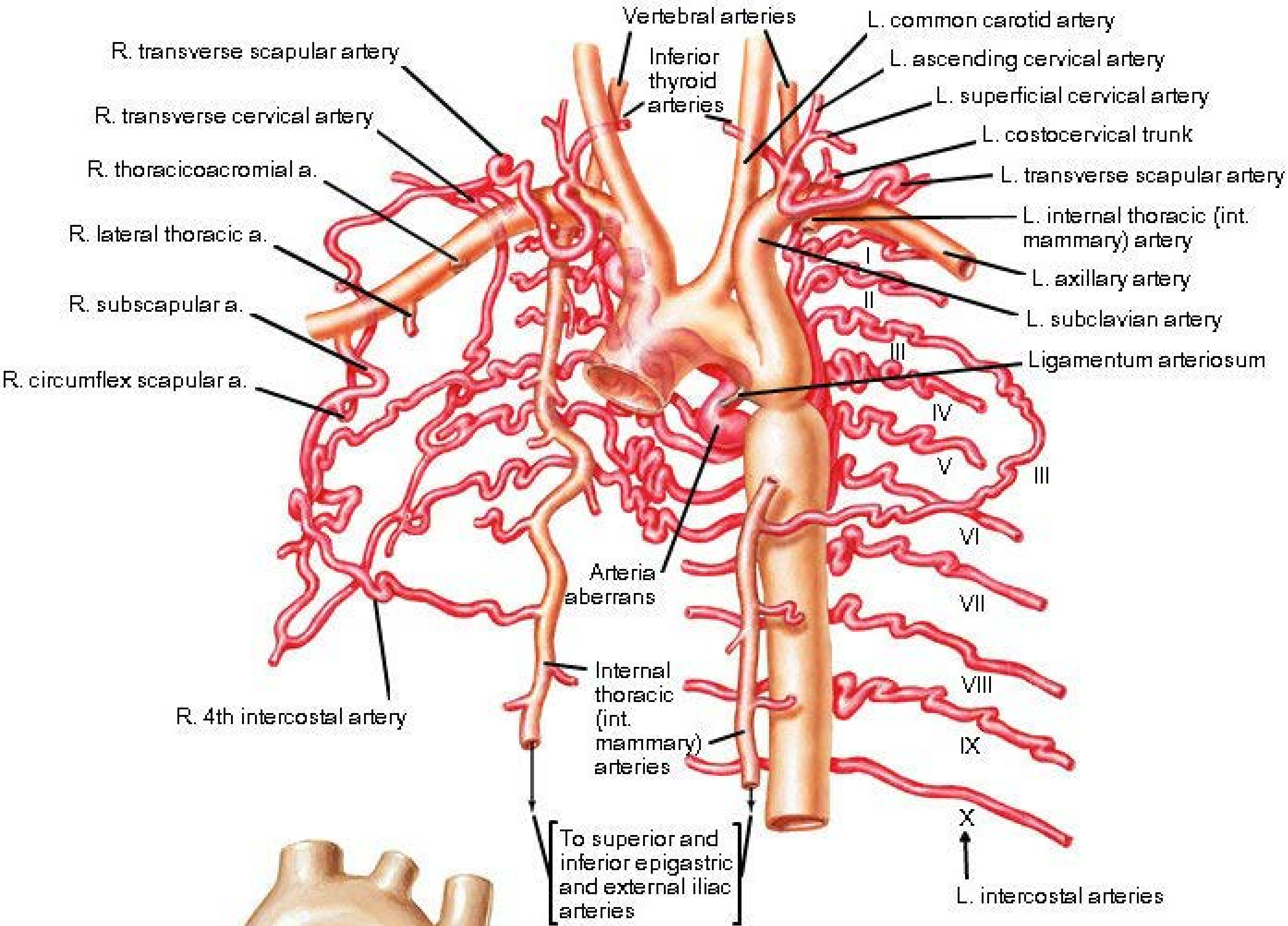


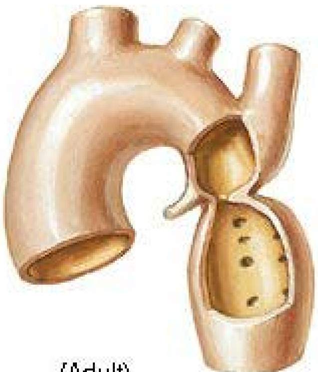
Artery Anomalies



Intersegmental Arteries and Coarctation of the Aorta

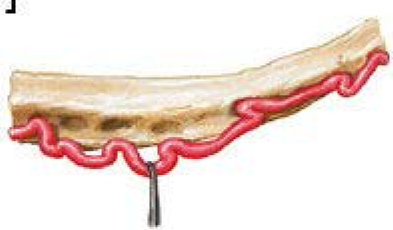
Coarctation of the aorta





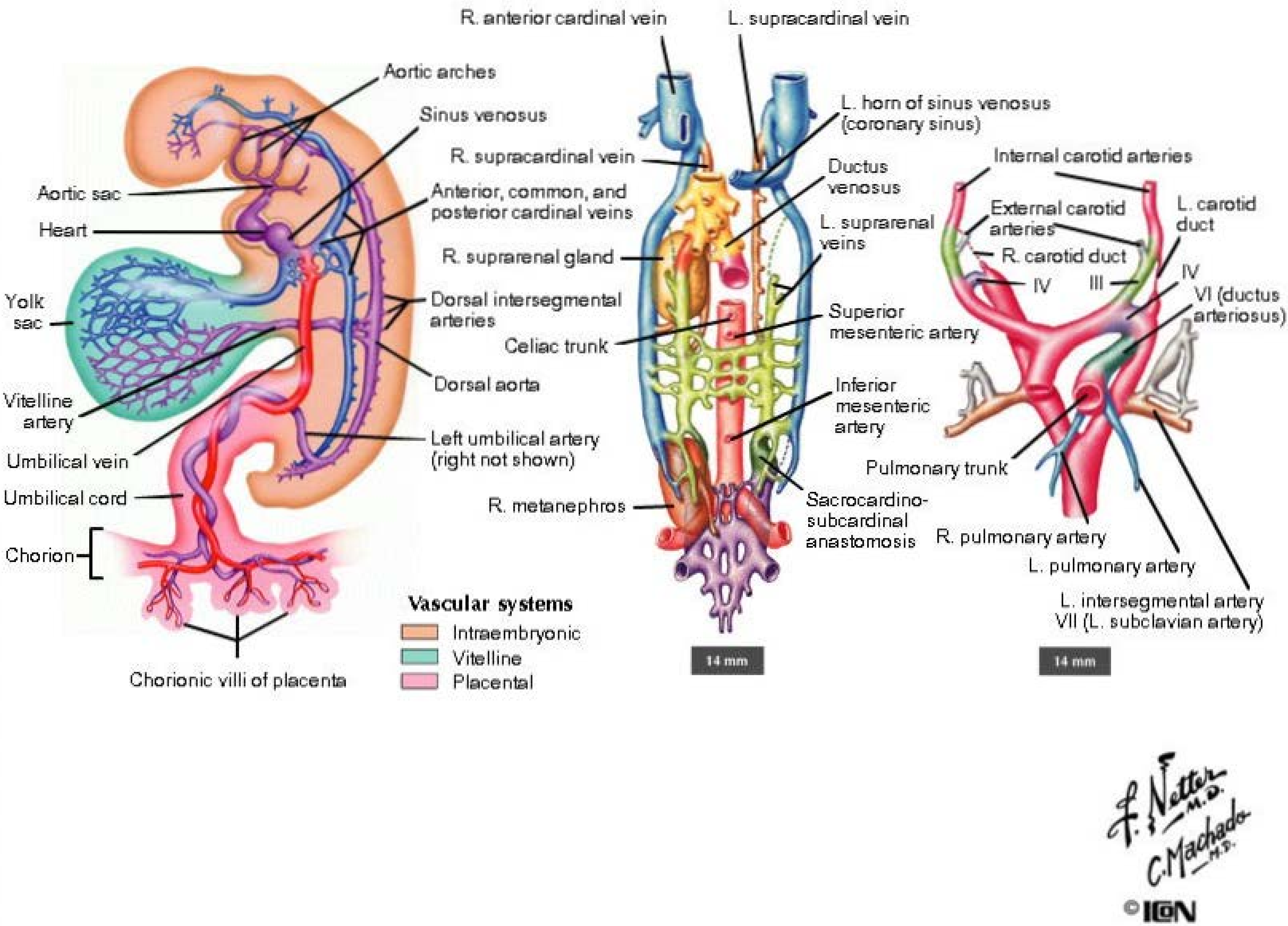
(Adult)
Postductal type

(Infant; 1 month)
Preductal type



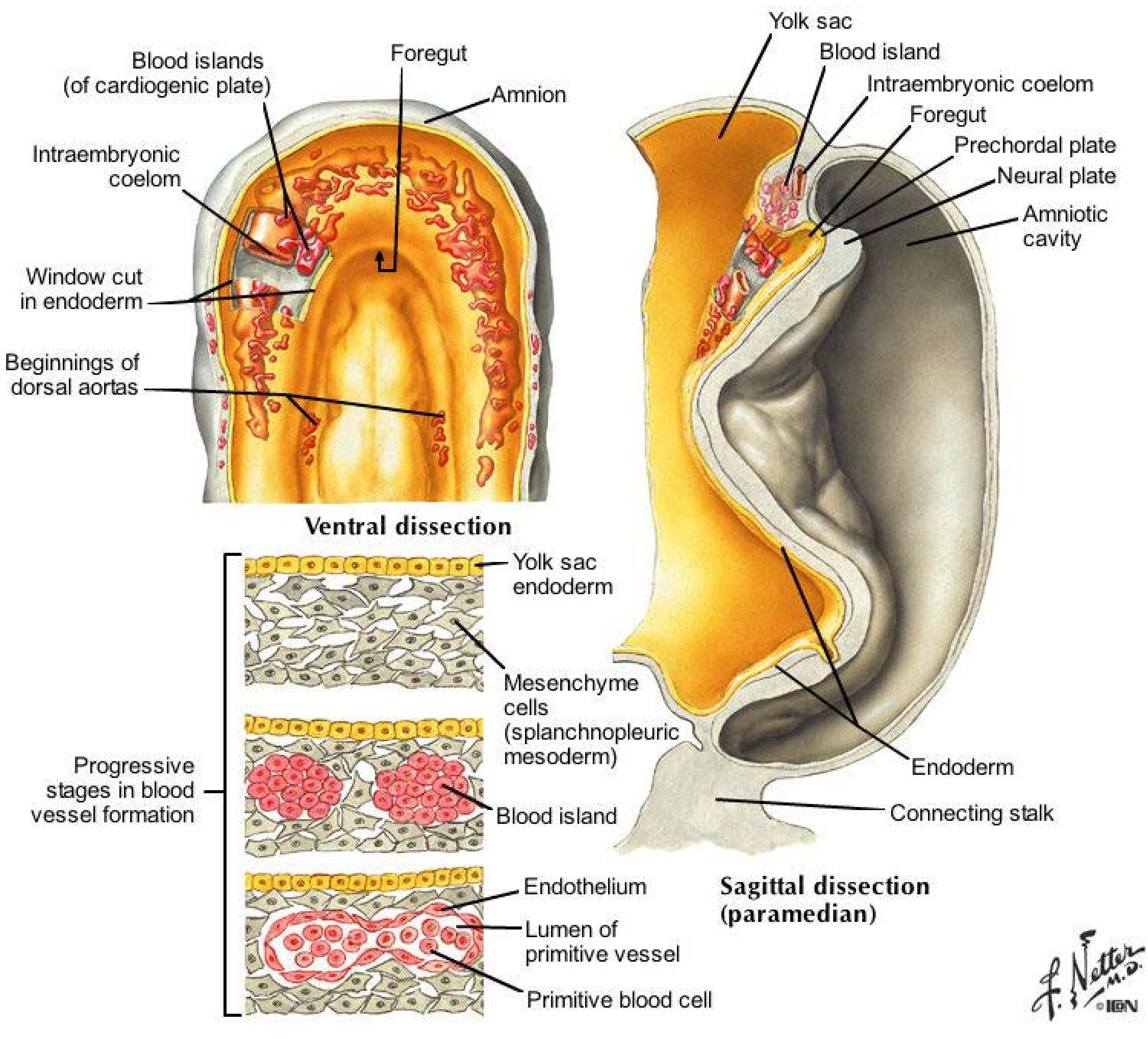
Intercostal artery retracted from rib, demonstrating erosion of costal groove by the tortuous vessel

Summary of Embryonic Blood Vesel Derivatives



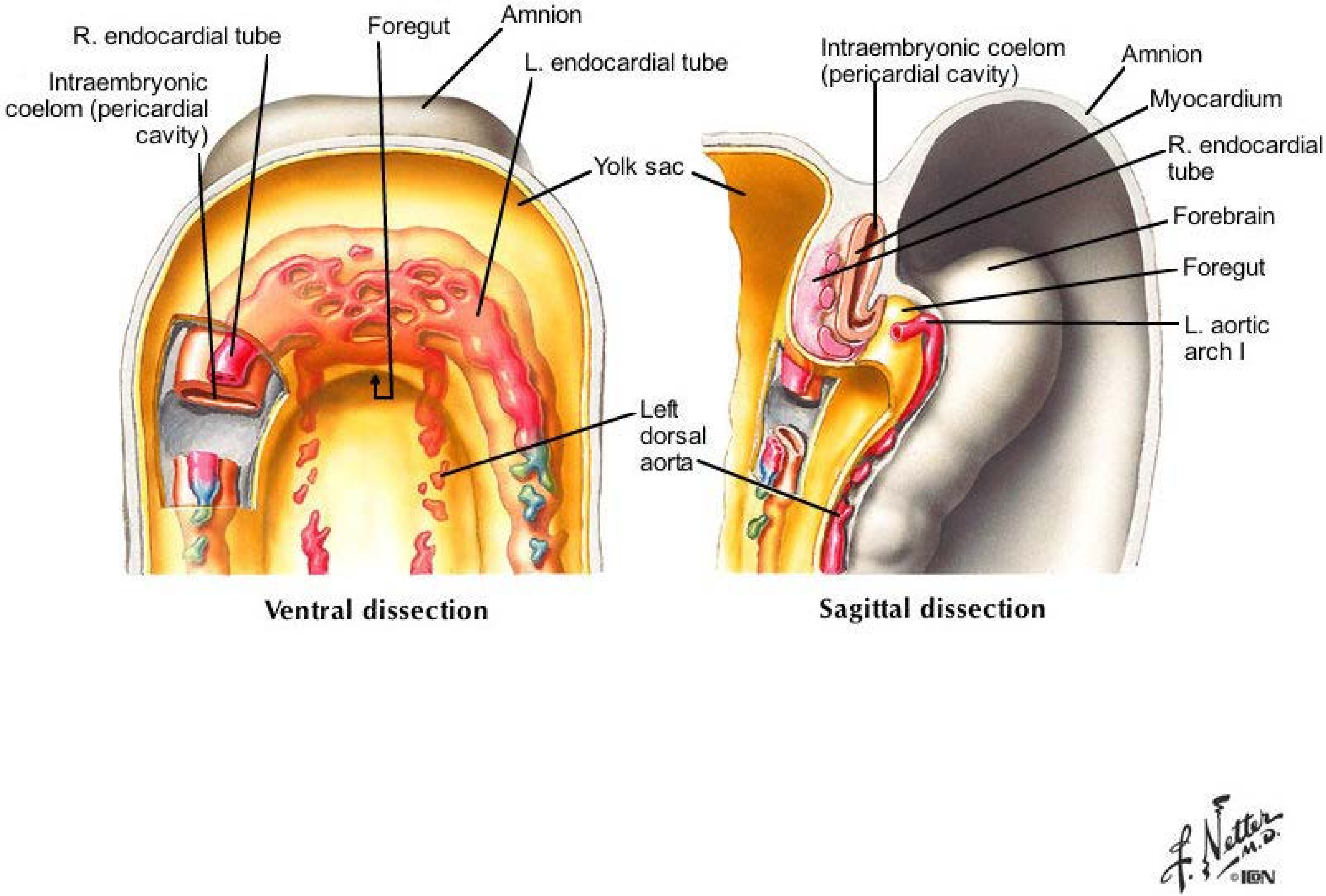
Formation of Blood Vessels

Presomite stage (1.5-mm embryo) at approximately 20 days



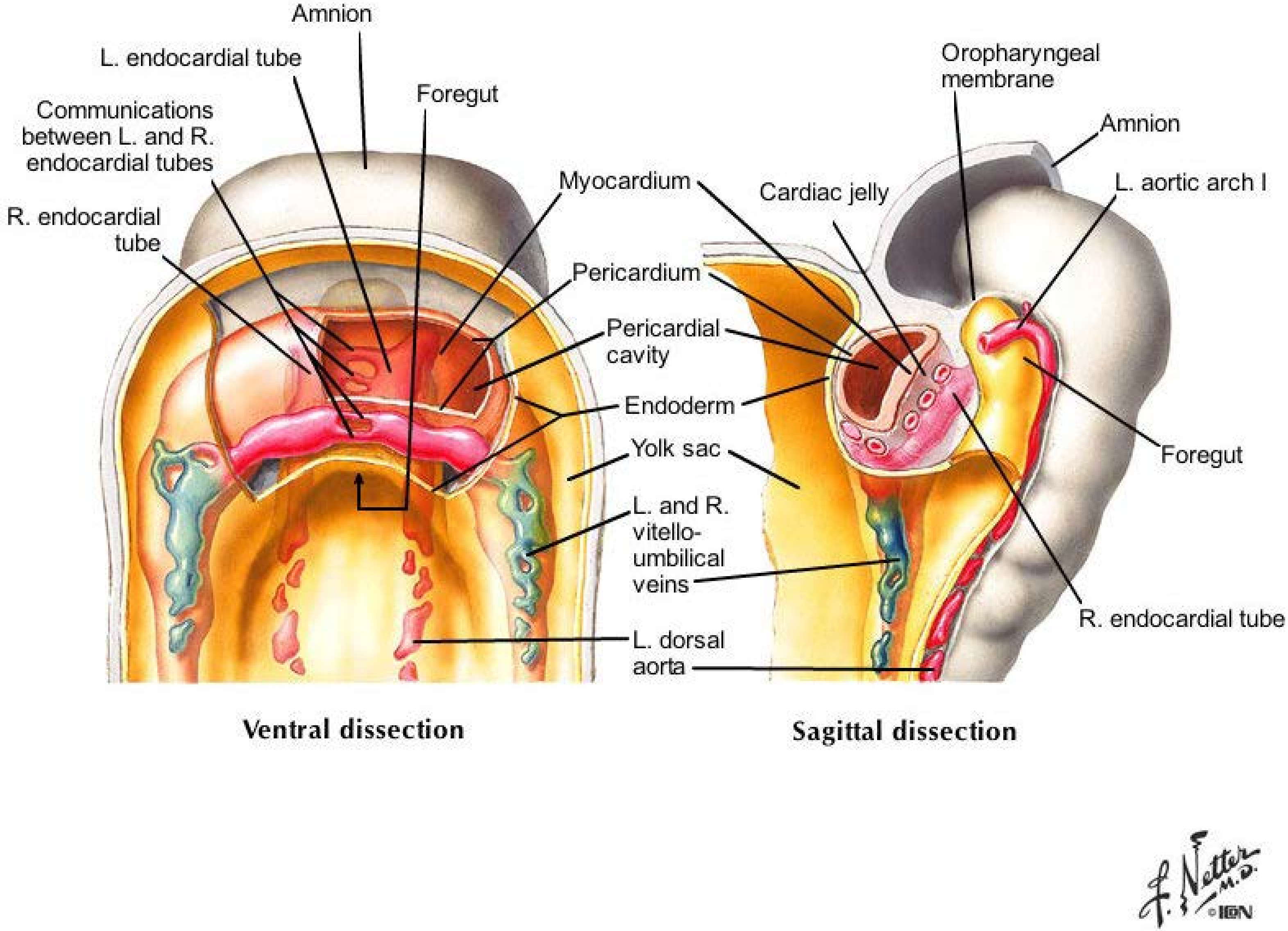
Formation of the Heart Tube

One-somite stage (1.5 mm) at approximately 20 days



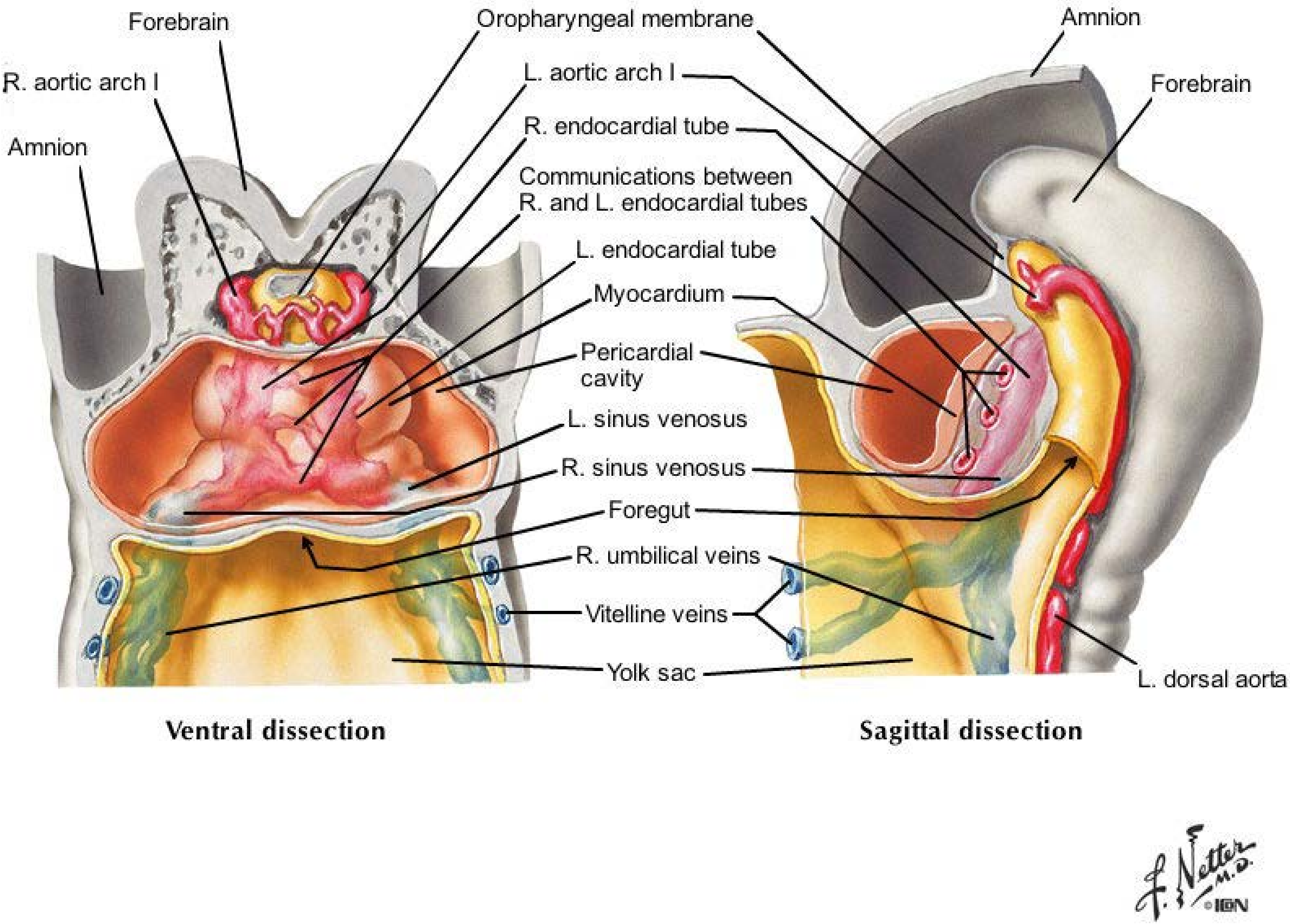
Formation of the Heart Tube

Two-somite stage (1.8 mm) at approximately 21 days



Ventral dissection **Sagittal dissection**

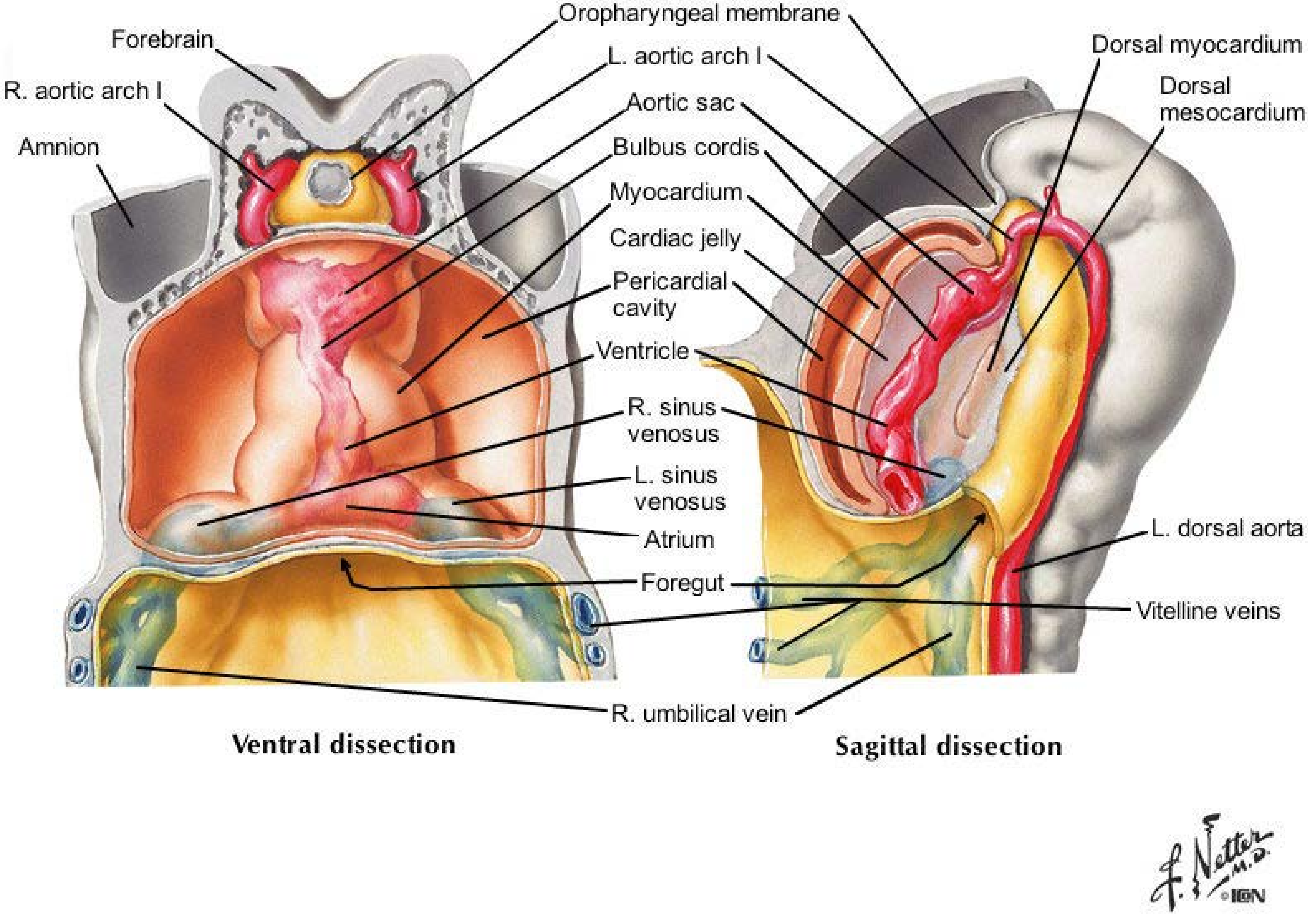
Formation of the Heart Tube
Four-somite stage (2.0 mm) at approximately 22 days



Ventral dissection **Sagittal dissection**

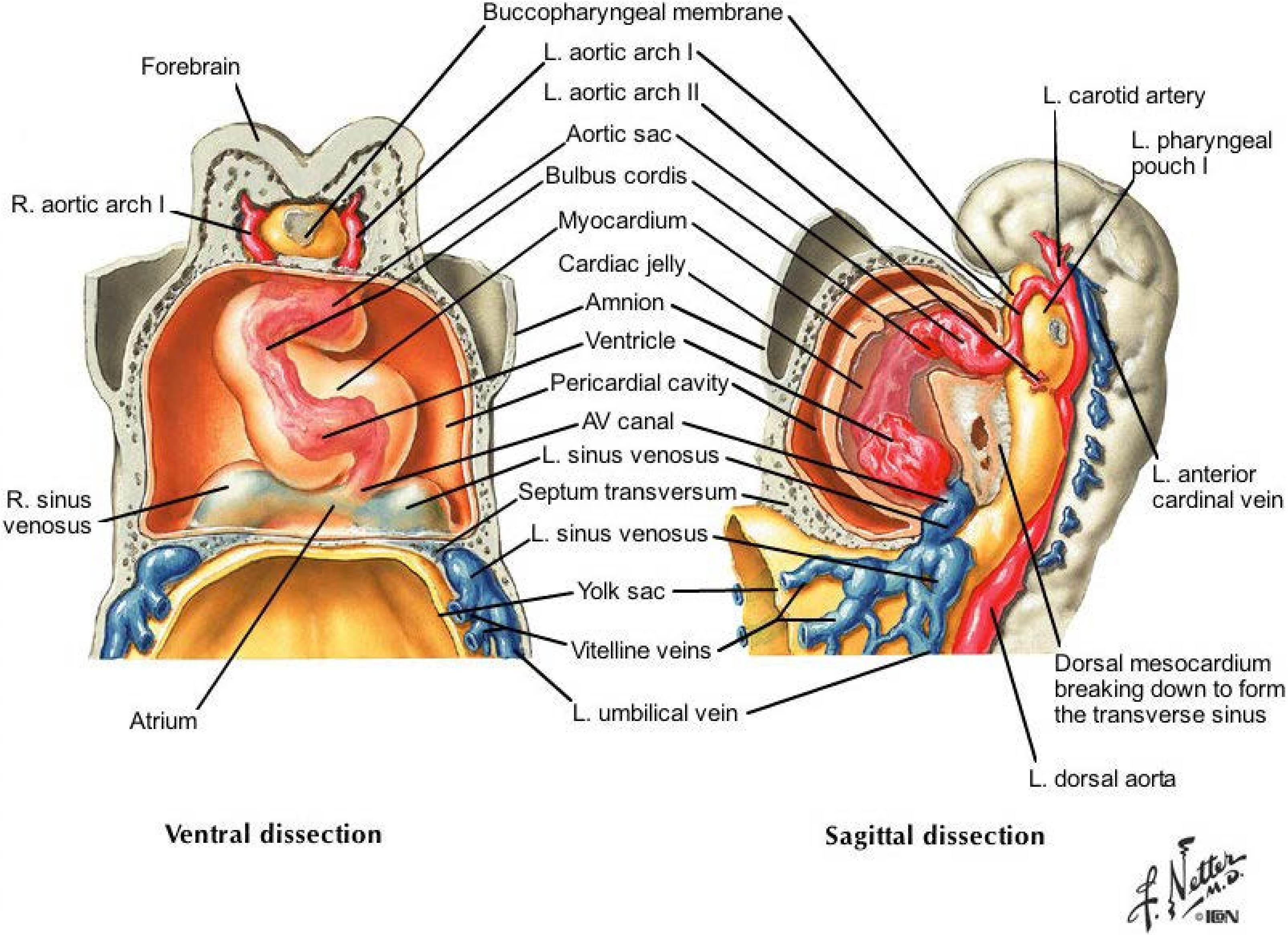
Formation of the Heart Tube

Seven-somite stage (2.2 mm) at approximately 23 days



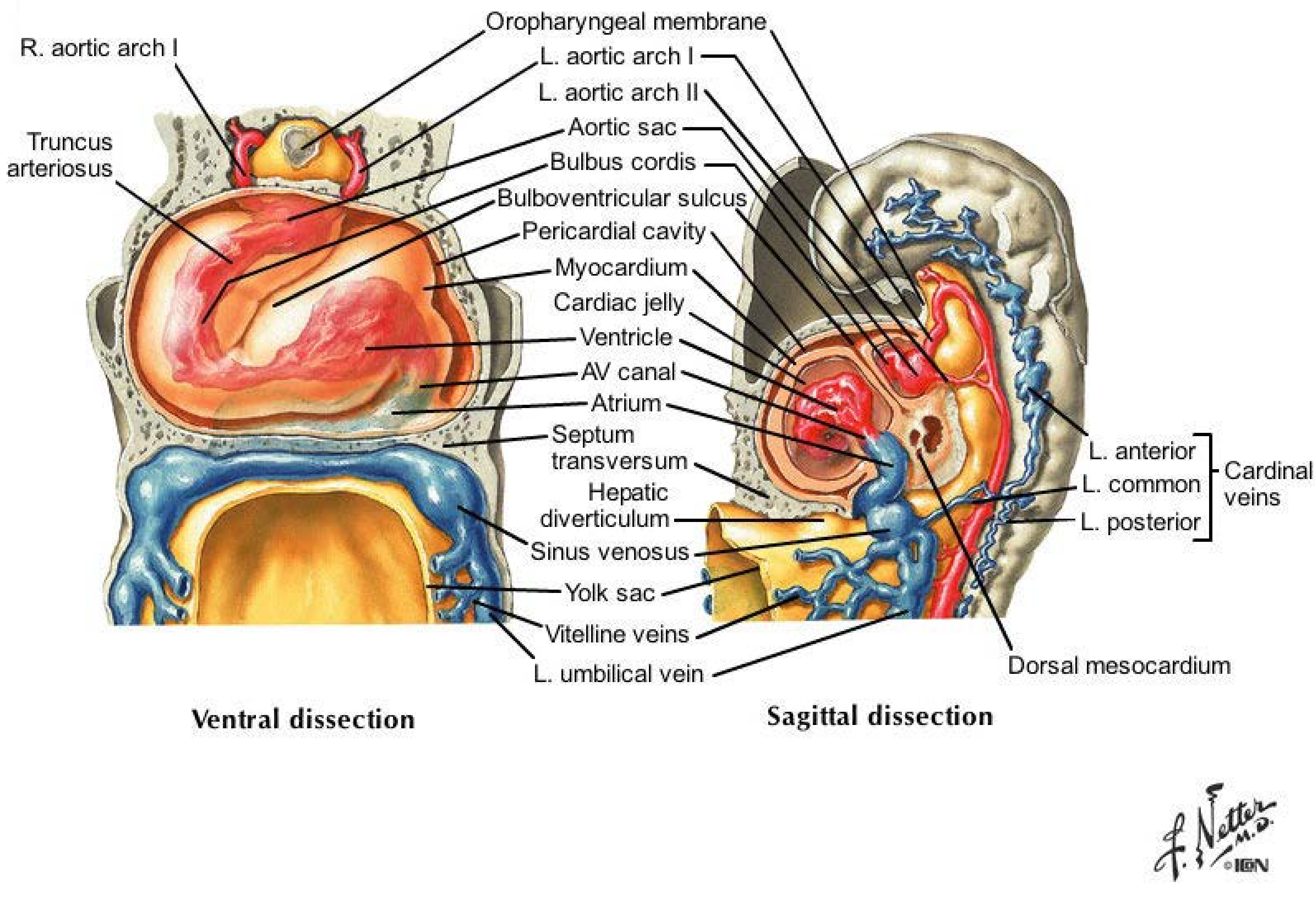
Chambers of the Heart Tube

Ten-somite stage (2.5 mm) at approximately 23 days

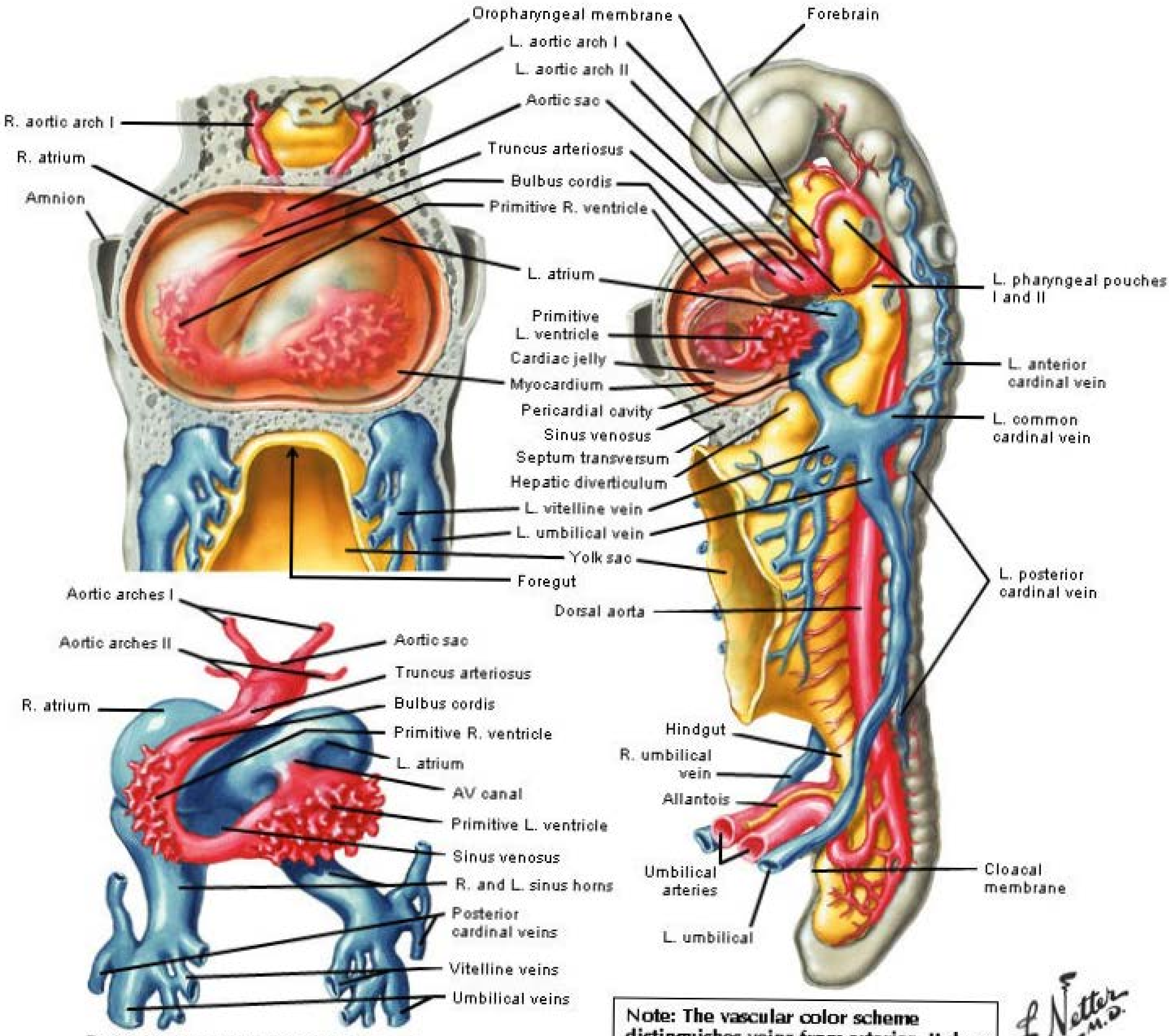


Chambers of the Heart Tube

Fourteen-somite stage (3.0 mm) at approximately 24 days



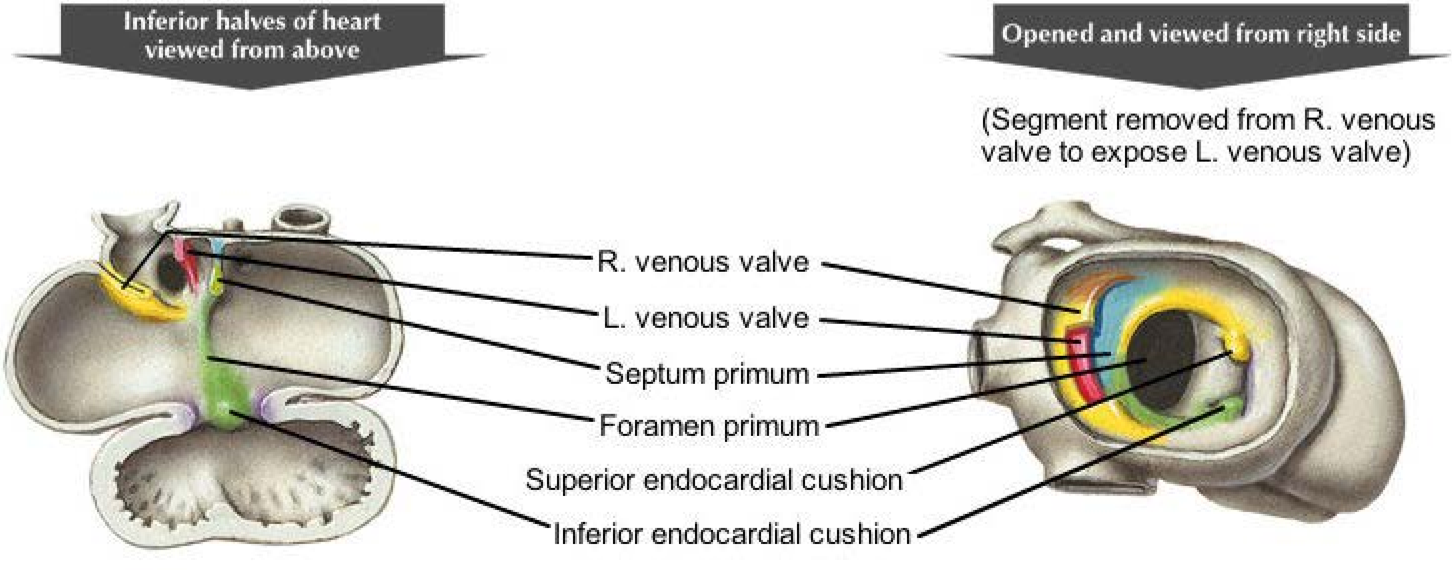
Bending of the Heart Tube
Twenty-somite stage (3.2 mm) at approximately 25 days



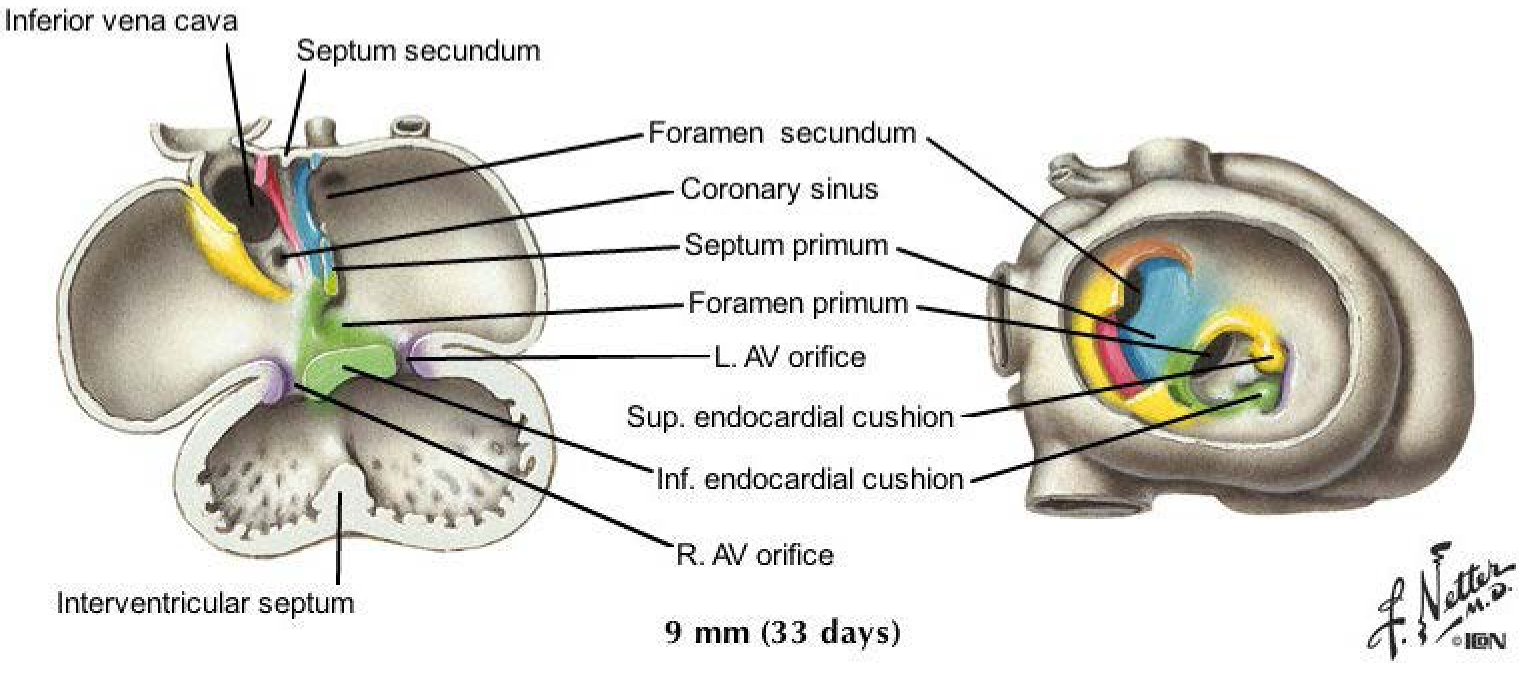
Endocardial tube with myocardium removed

Note: The vascular color scheme distinguishes veins from arteries. It does not reflect blood oxygenation levels.

Partitioning the Heart Tube

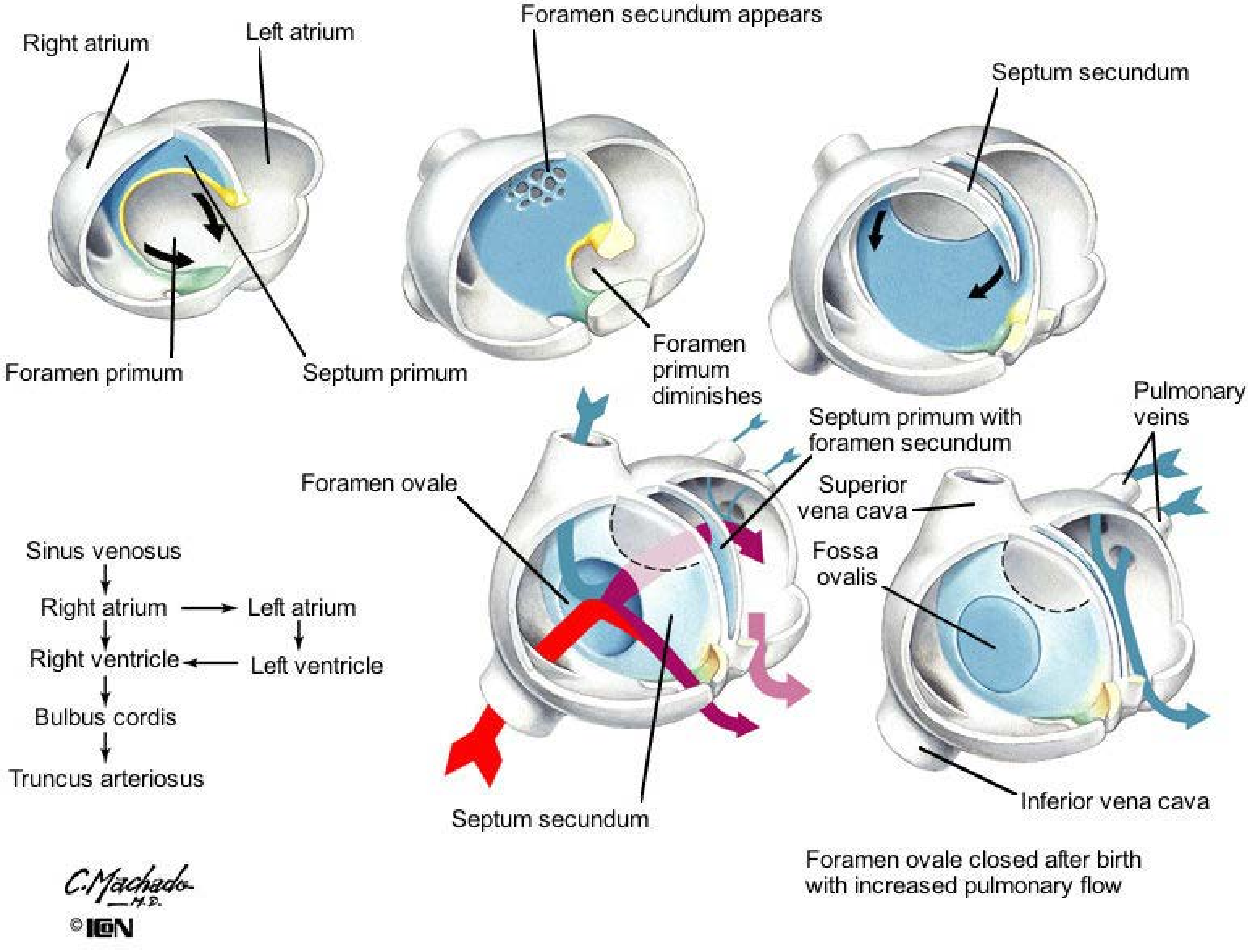


6.5 mm (29 days)

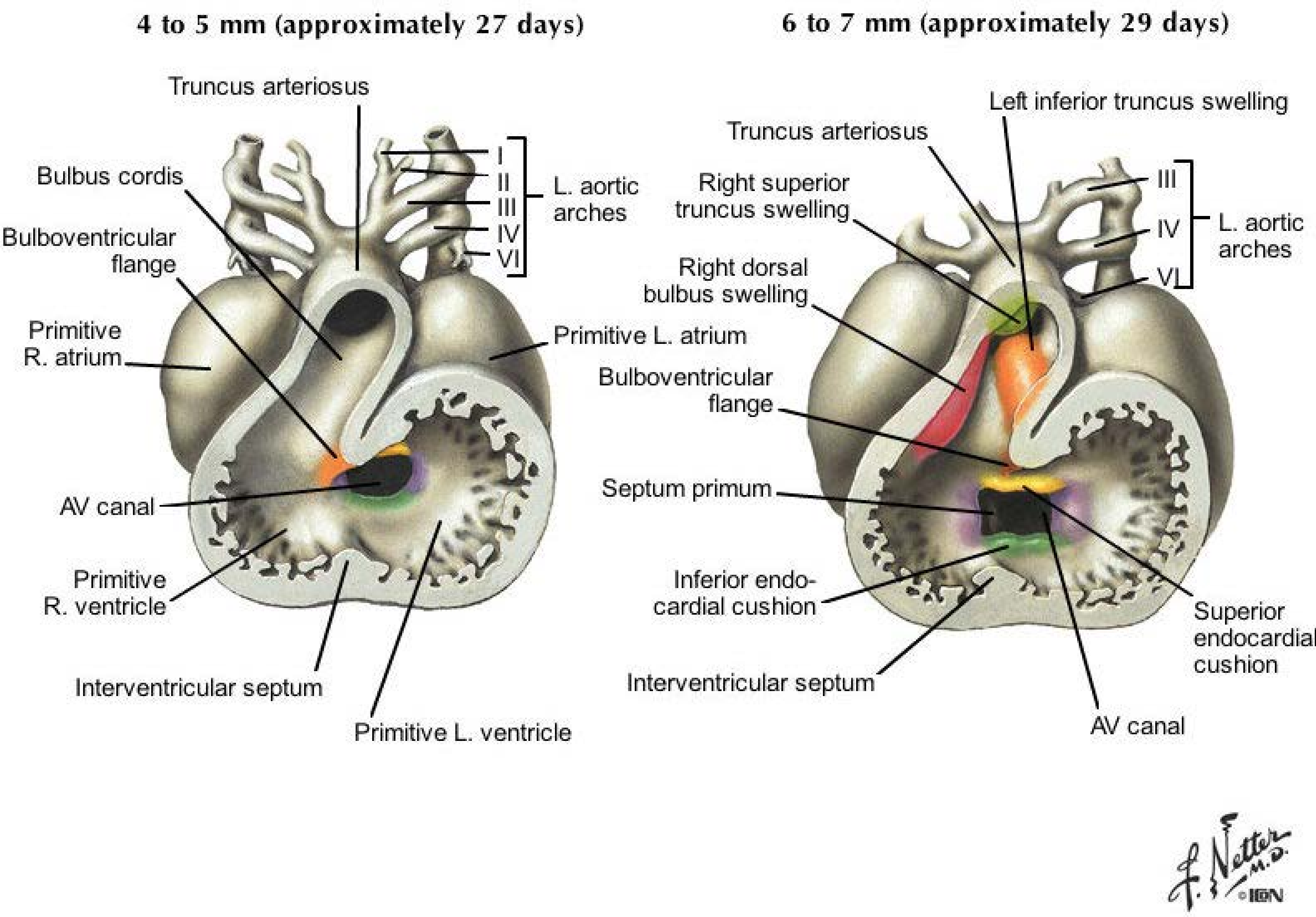


9 mm (33 days)

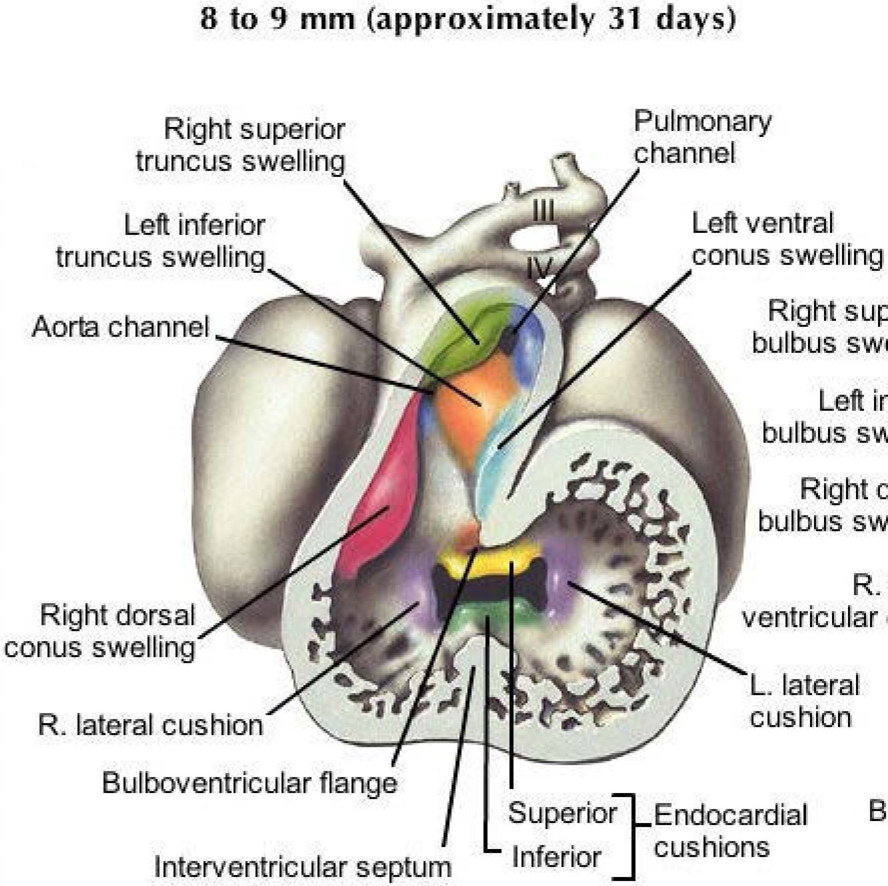
Atrial Separation

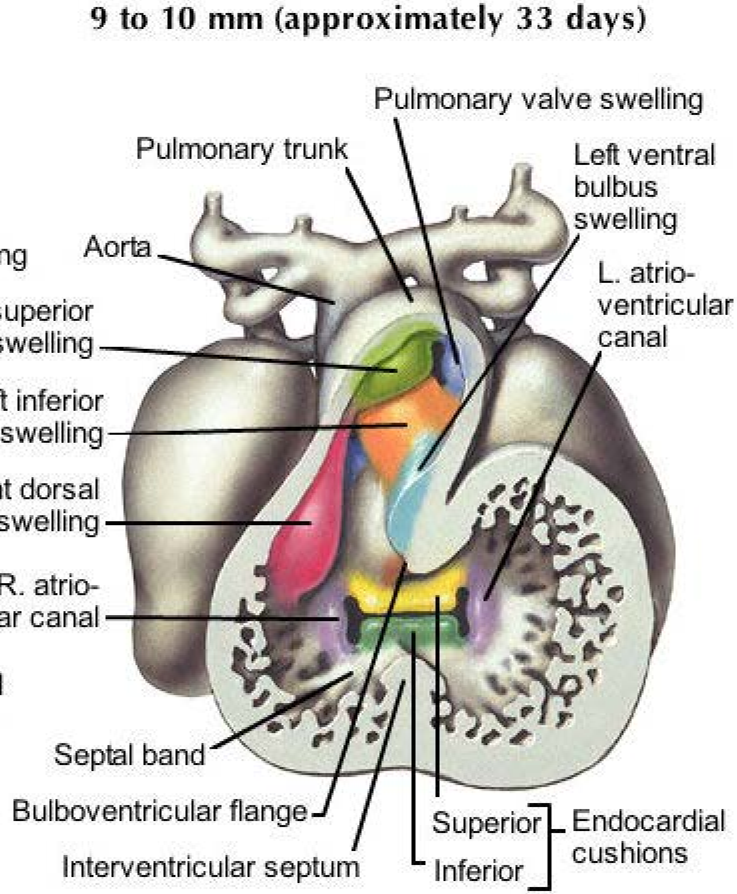


Spiral (Aorticopulmonary) Septum



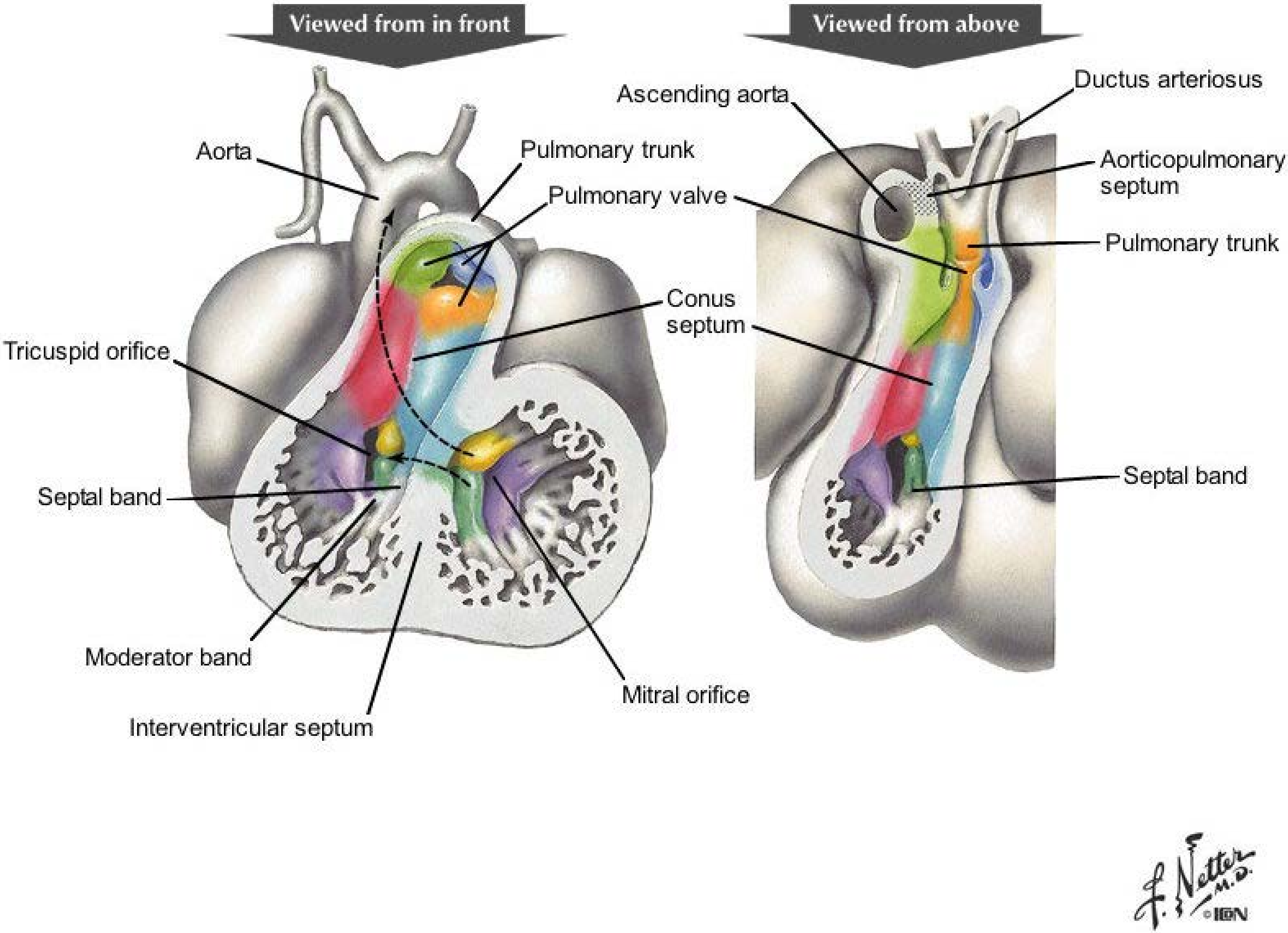
Spiral (Aorticopulmonary) Septum





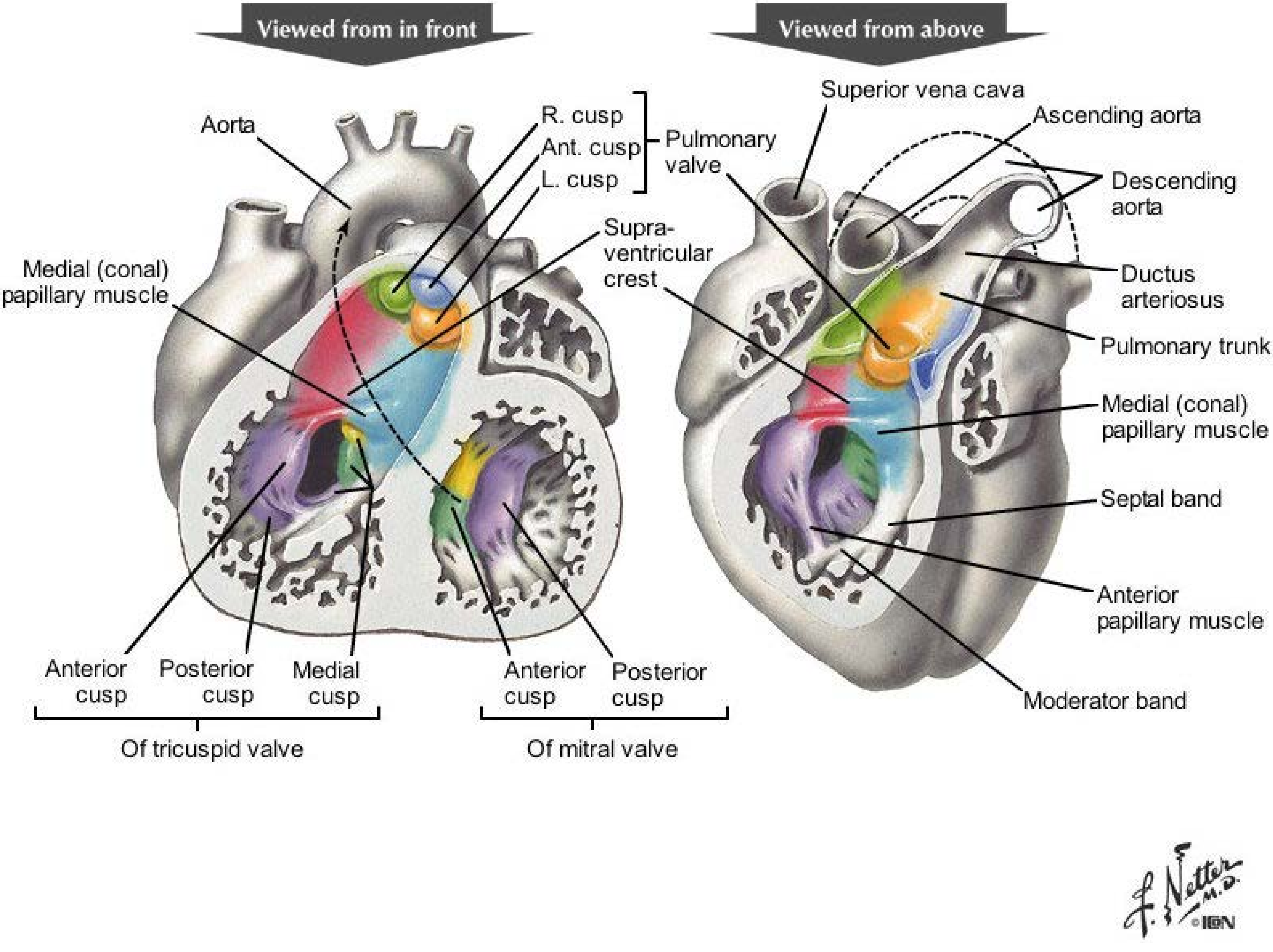
Completion of the Spiral (Aorticopulmonary) Septum

16 mm (approximately 37 days)

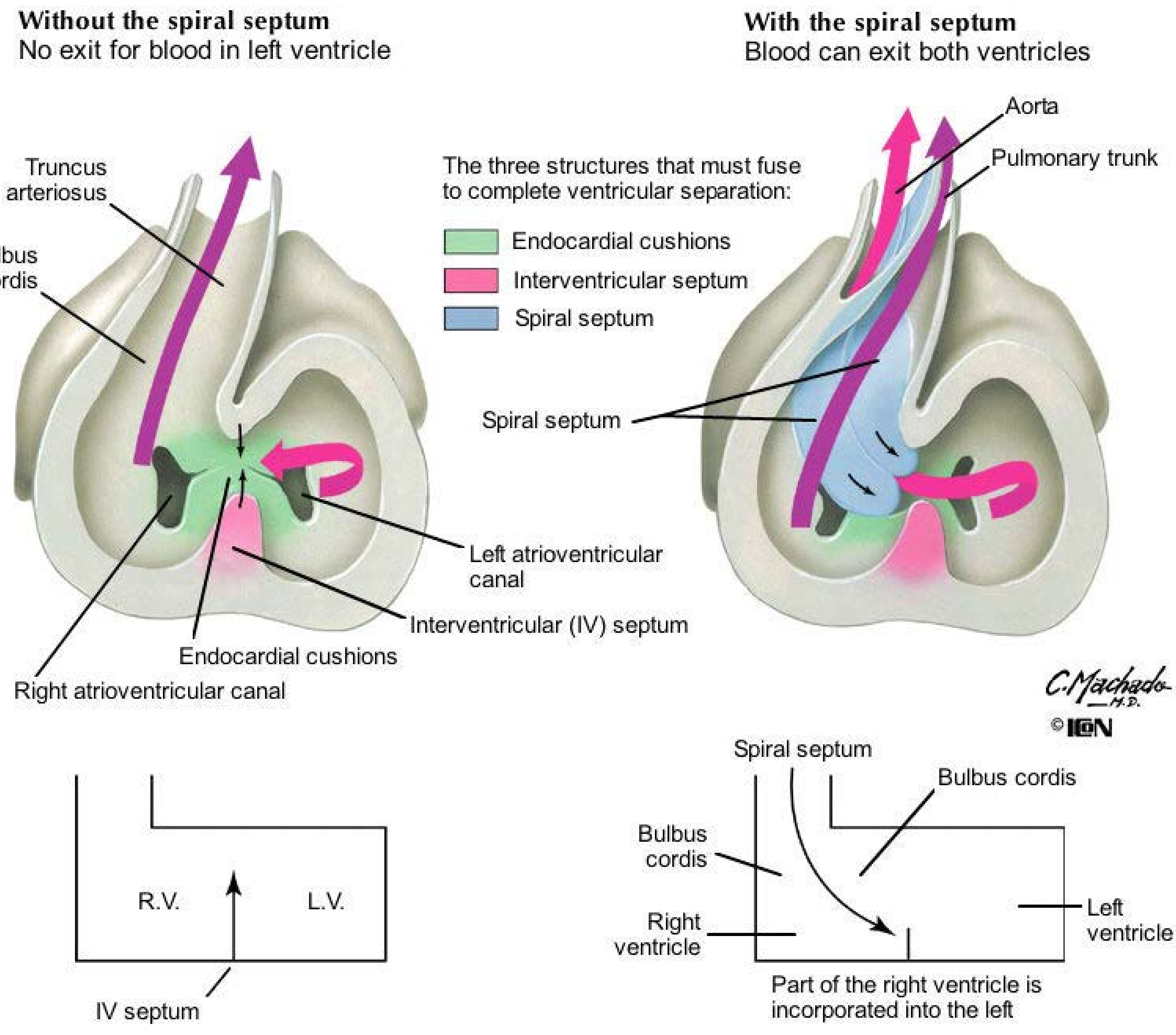


Completion of the Spiral (Aorticopulmonary) Septum

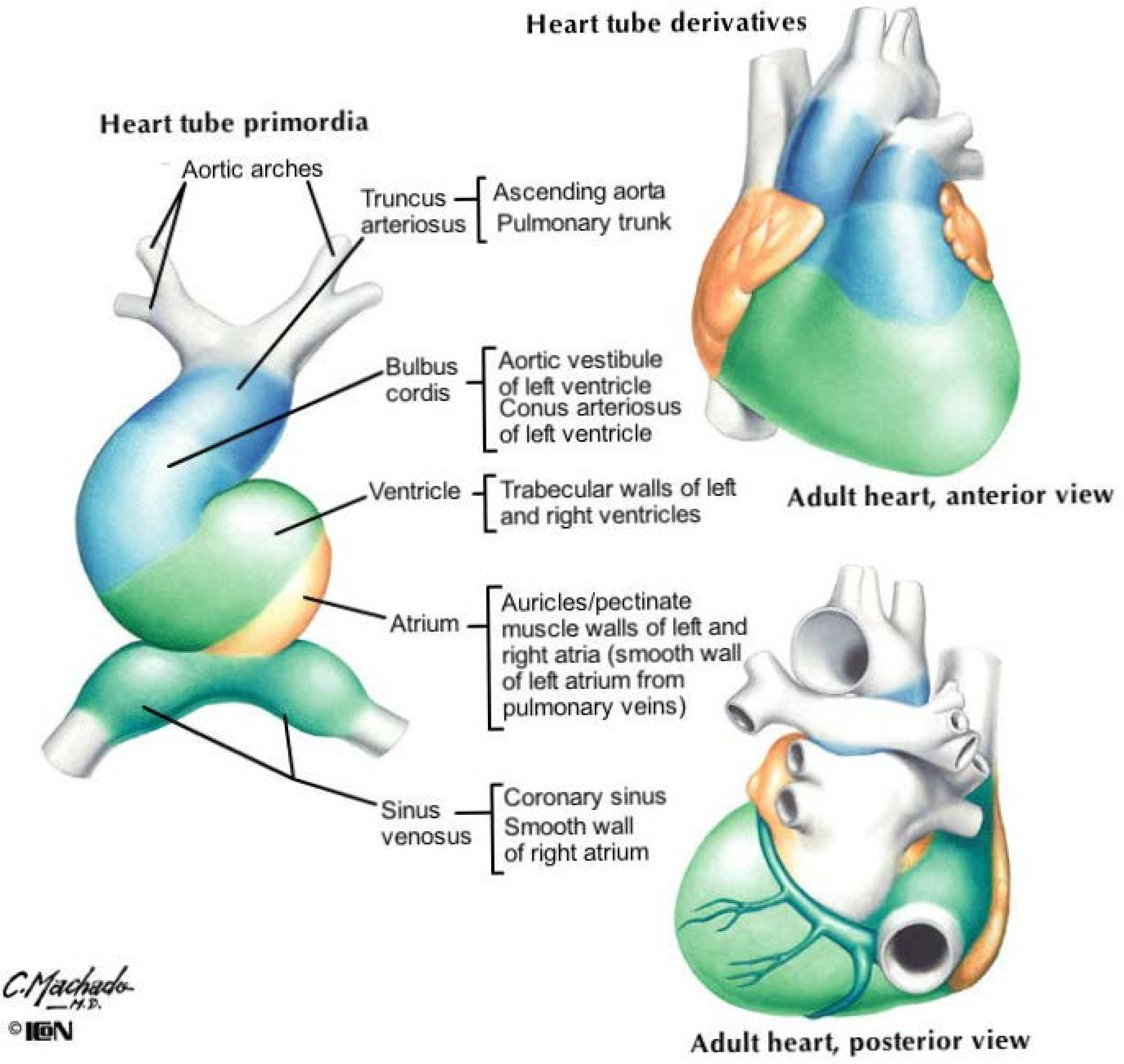
40 mm (approximately 55 days)



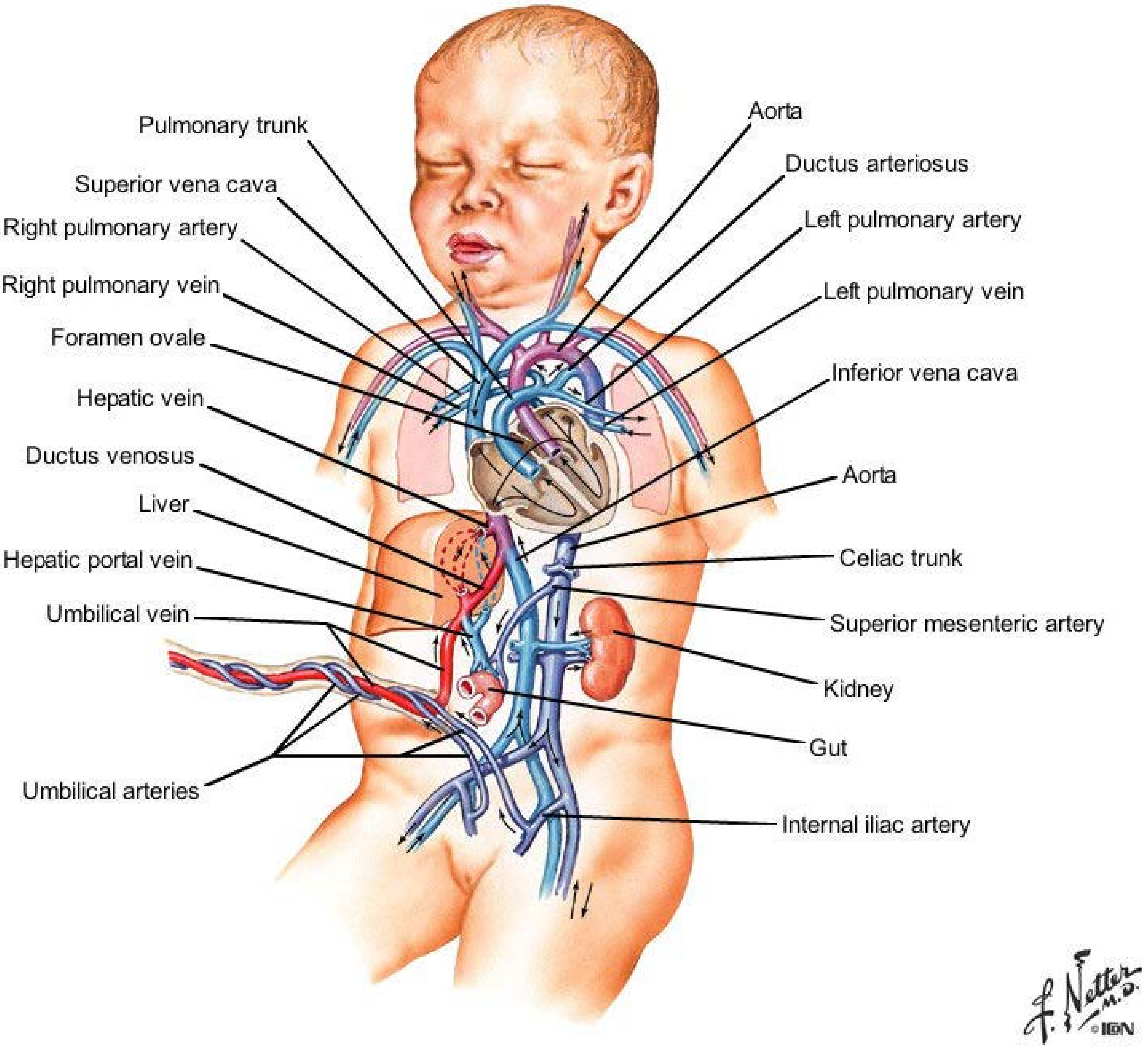
Ventricular Separtion and Bulbus Cordis



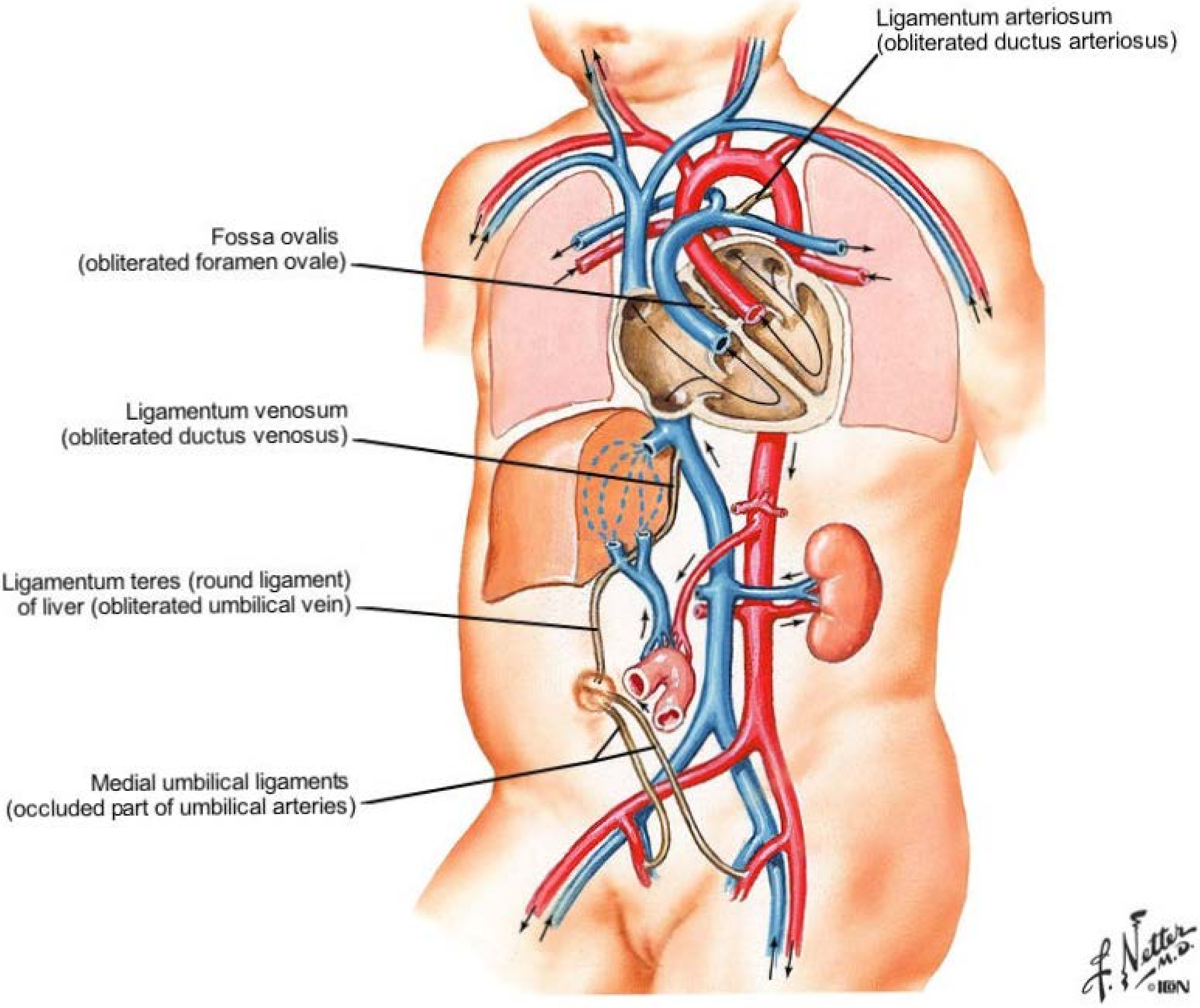
Adult Derivatives of the Heart Tube Chambers



Fetal Circulation



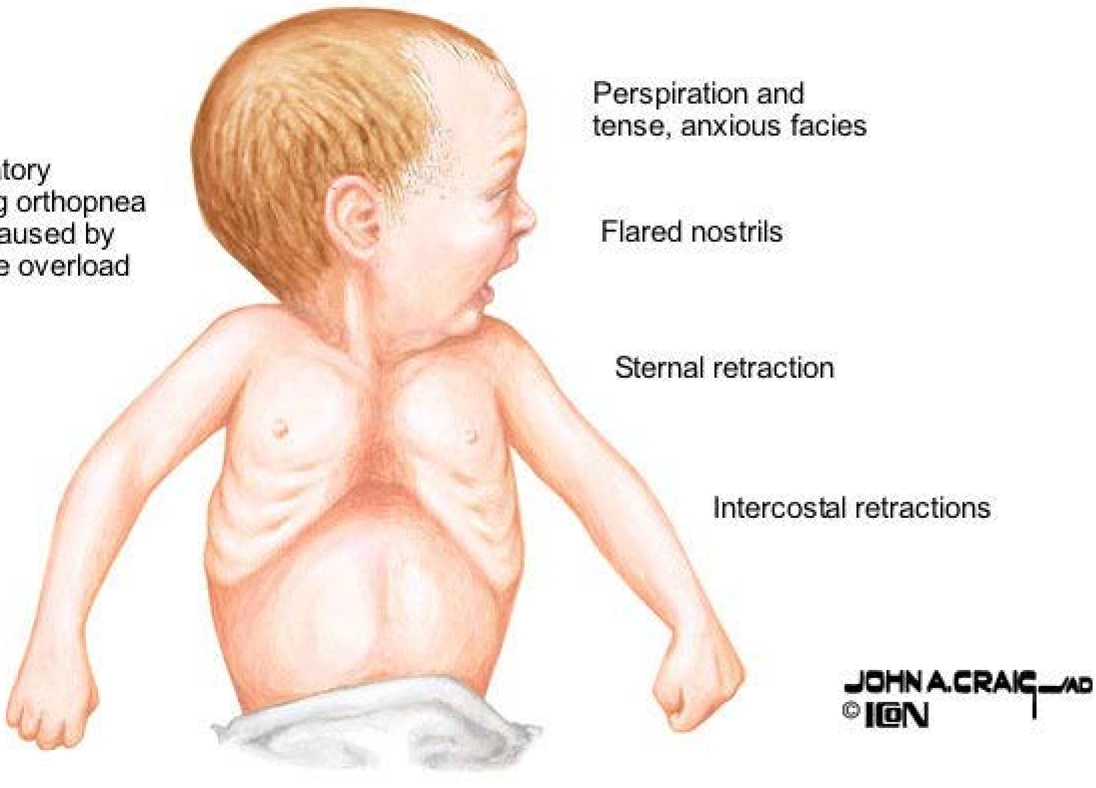
Transition to Postnatal Circulation



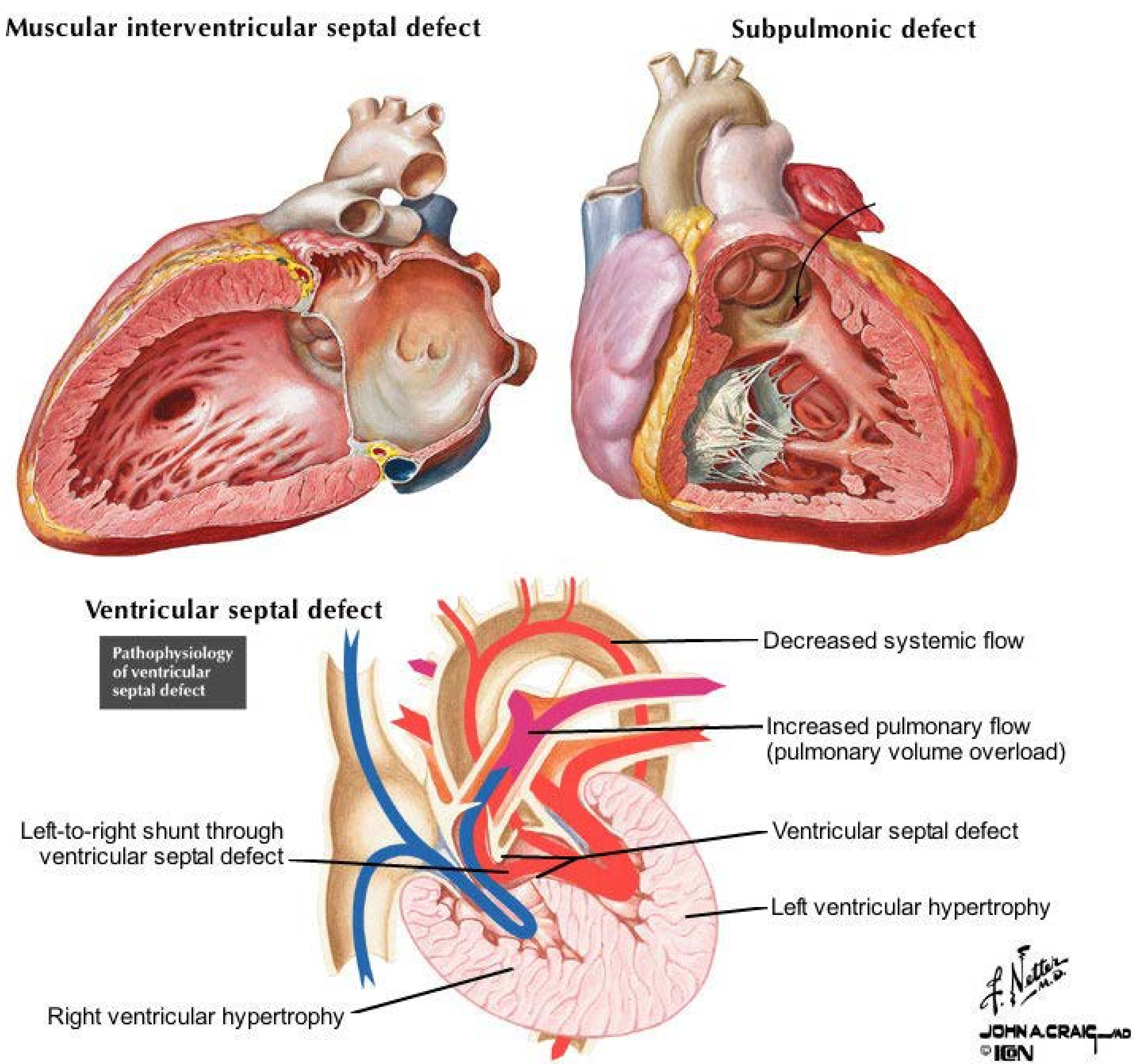
Congenital Heart Defect Concepts

Clinical characteristics of too little pulmonary flow

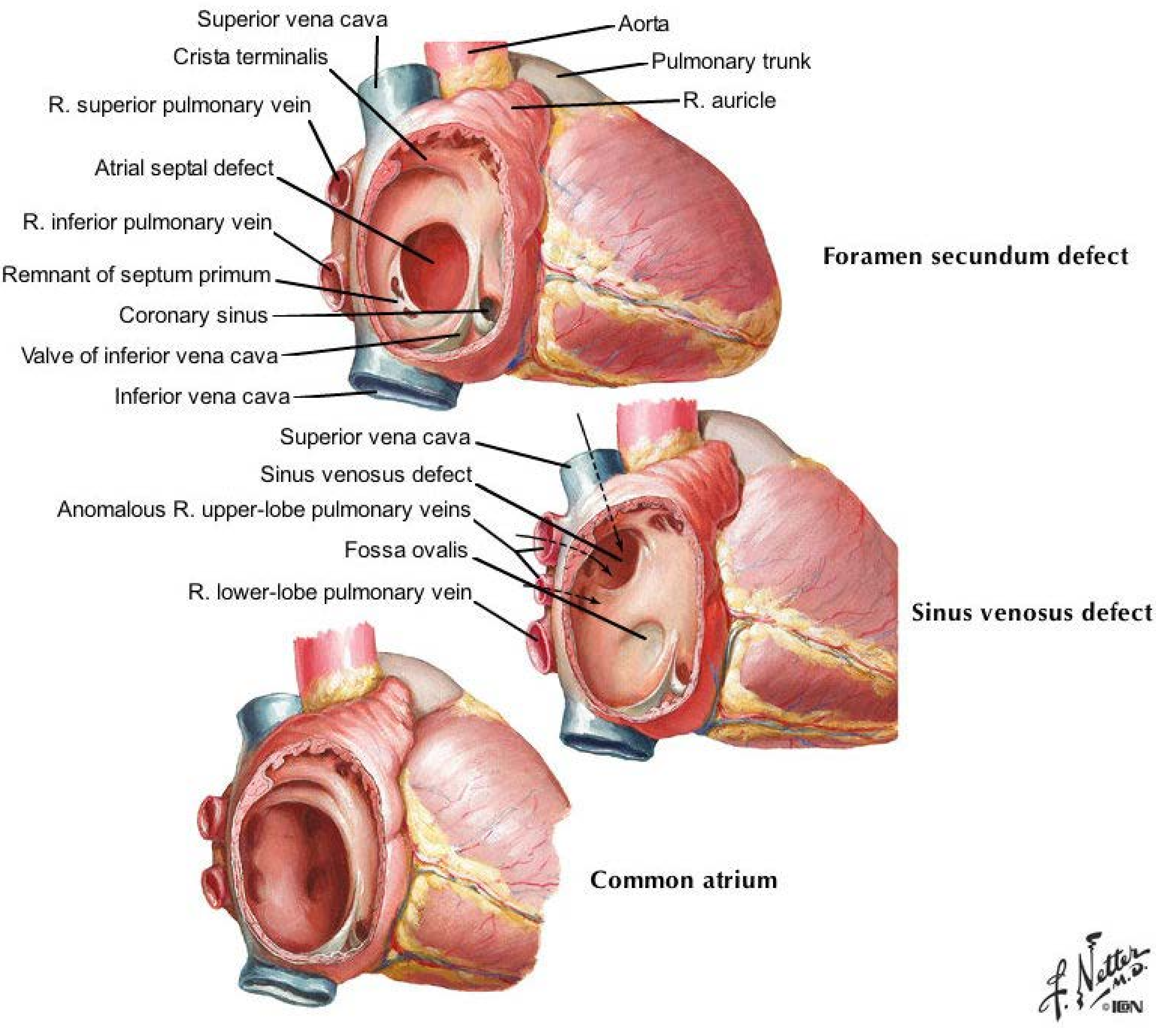
Clinical characteristics of too much pulmonary flow (pulmonary volume overload)



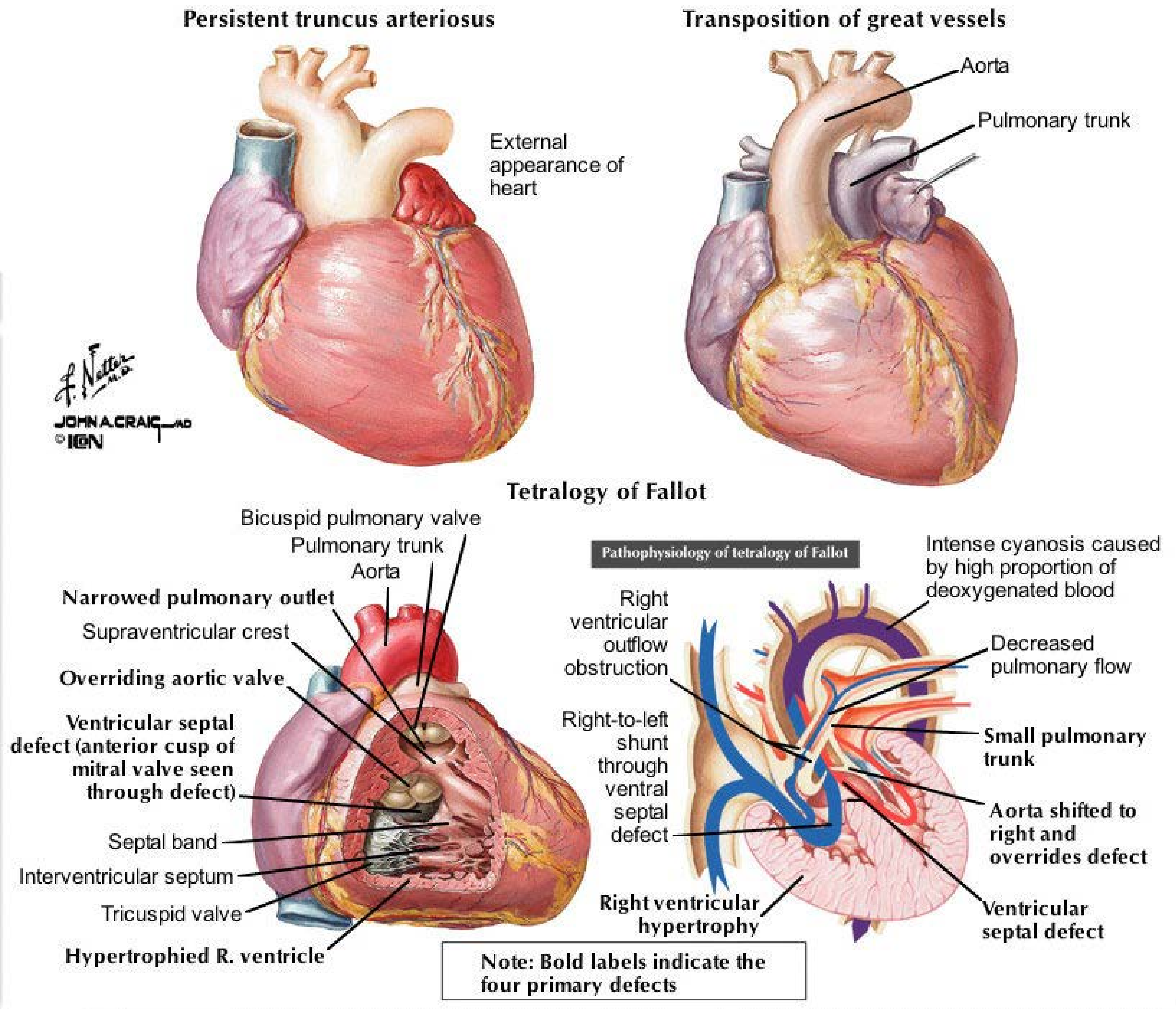
Ventricular Septal Defects



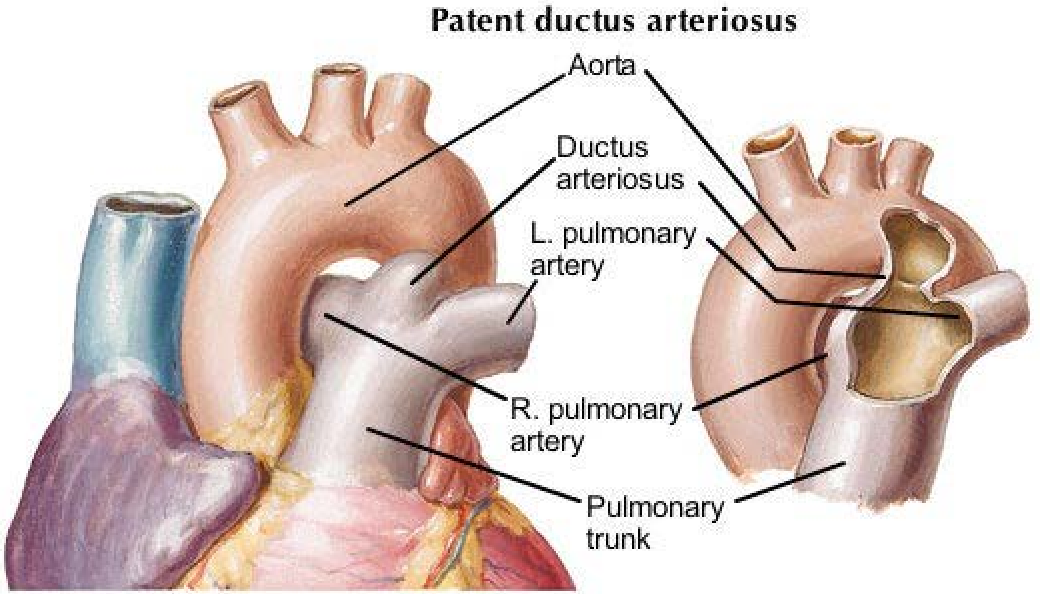
Atrial Septal Defects



Spiral Septum Defects



Patent Ductus Arteriosus



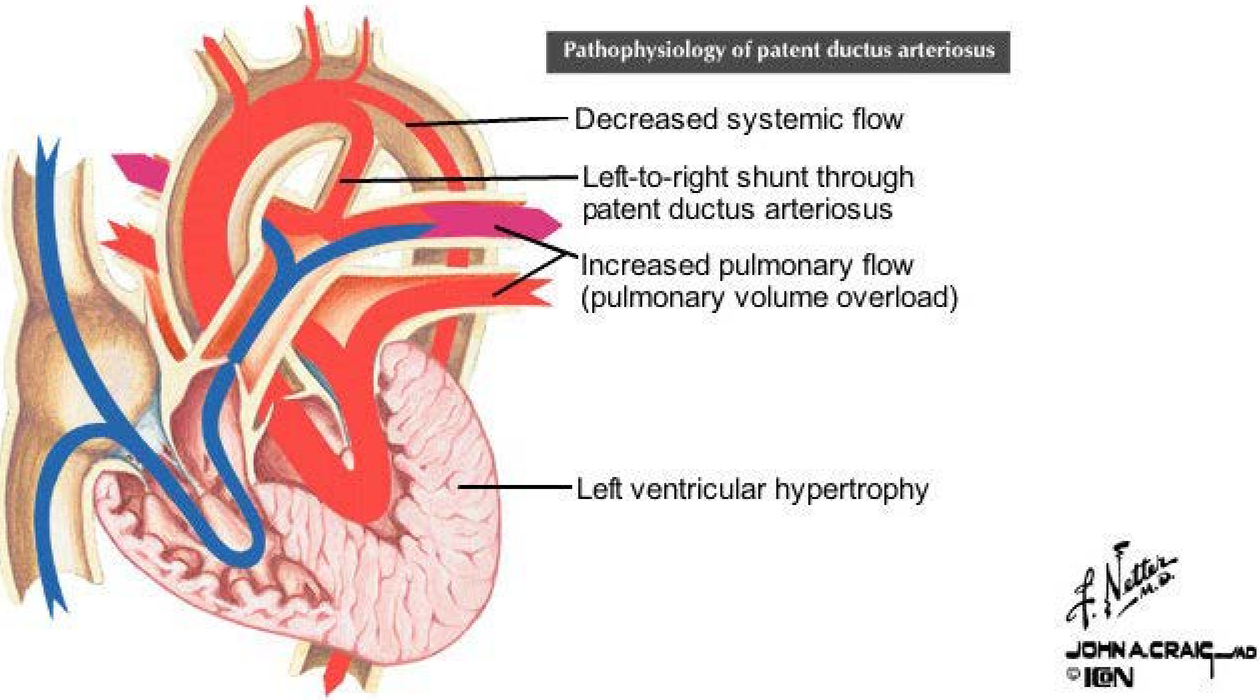
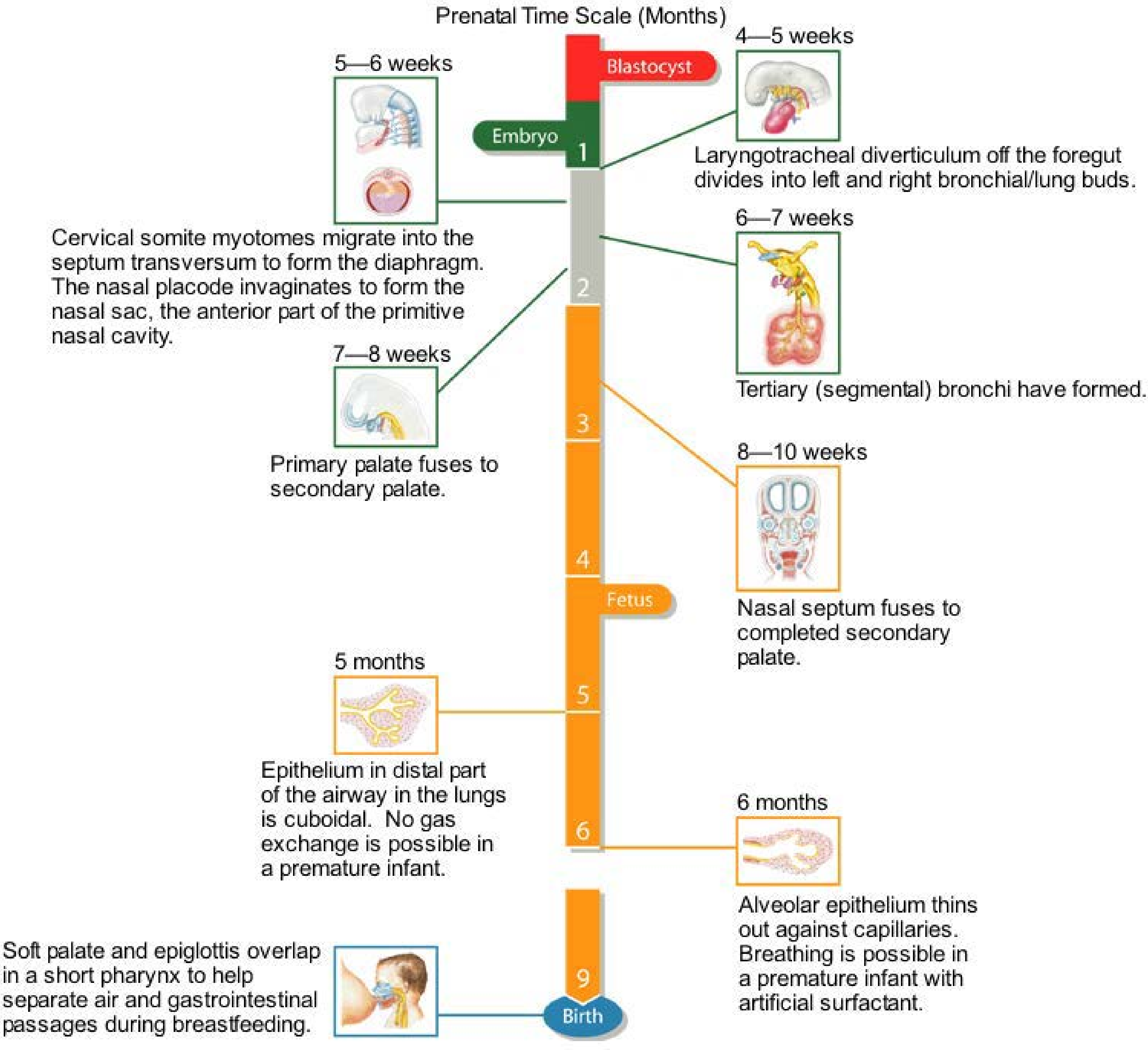


Chart 4.1 Embryonic Blood Vessel Derivatives

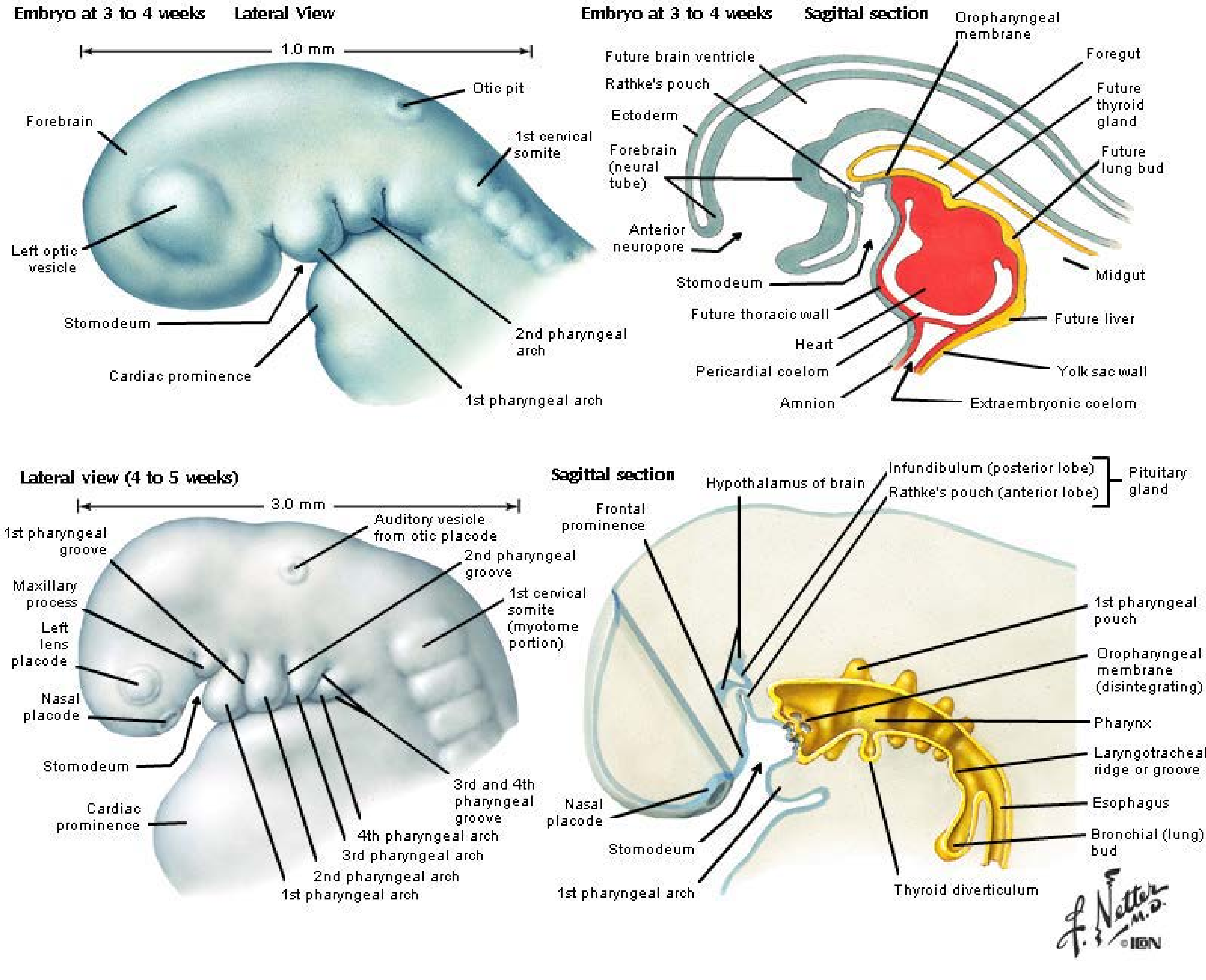
CHART 4.1 EMBRYONIC BLOOD VESSEL DERIVATIVES

Embryonic Vessels	Major Derivatives
Aortic arch artery 1	Part of maxillary arteries
Aortic arch artery 3	Common and internal carotid arteries
Aortic arch artery 4	Right subclavian artery; part of aortic arch
Aortic arch artery 6	Ductus arteriosus; proximal pulmonary arteries
Intersegmental arteries	Intercostal arteries Lumbar arteries Common iliac arteries Parts of vertebral, subclavian, and lateral sacral arteries
Umbilical arteries	Medial umbilical ligaments on the internal aspect of the abdominal wall
Umbilical vein	Round ligament of the liver (ligamentum teres)
Vitelline arteries	Celiac trunk Superior mesenteric artery Inferior mesenteric artery
Vitelline veins	Hepatic portal system Hepatic veins Intrahepatic segment of the inferior vena cava
Anterior cardinal veins	Superior vena cava Brachiocephalic (innominate) veins Internal jugular veins
Subcardinal veins (and anastomoses between the systems)	Lower inferior vena cava Renal and suprarenal veins Gonadal veins
Supracardinal veins	Azygous system of veins Segment of the inferior vena cava between the kidneys and liver

THE RESPIRATORY SYSTEM
TIMELINE

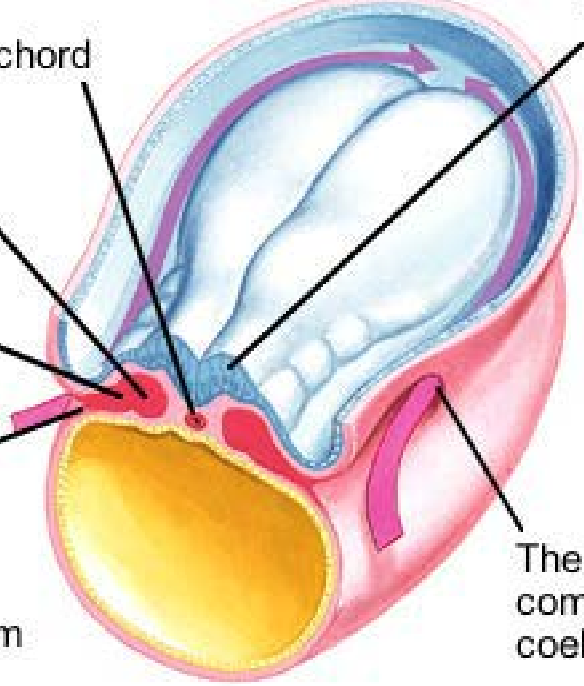


Early Primordia

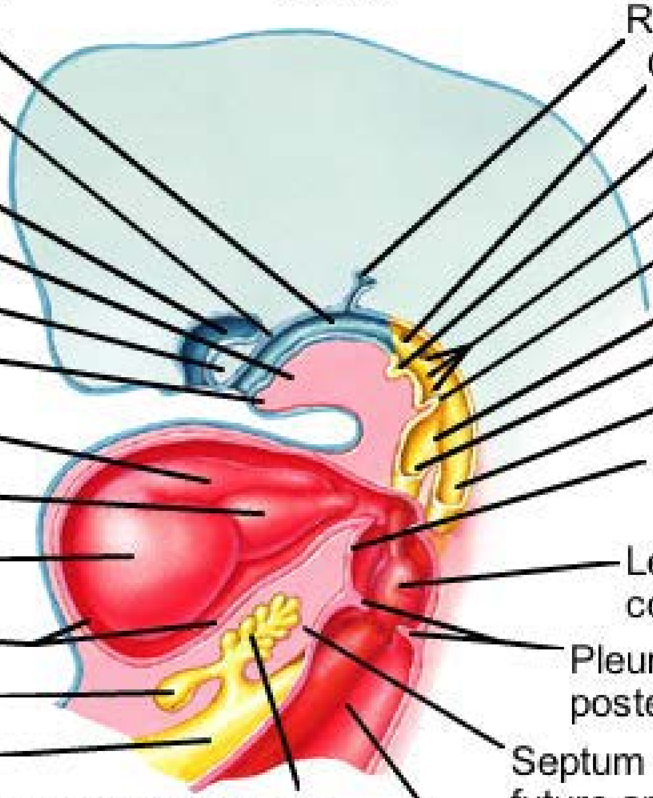


Formation of the Pleural Cavities

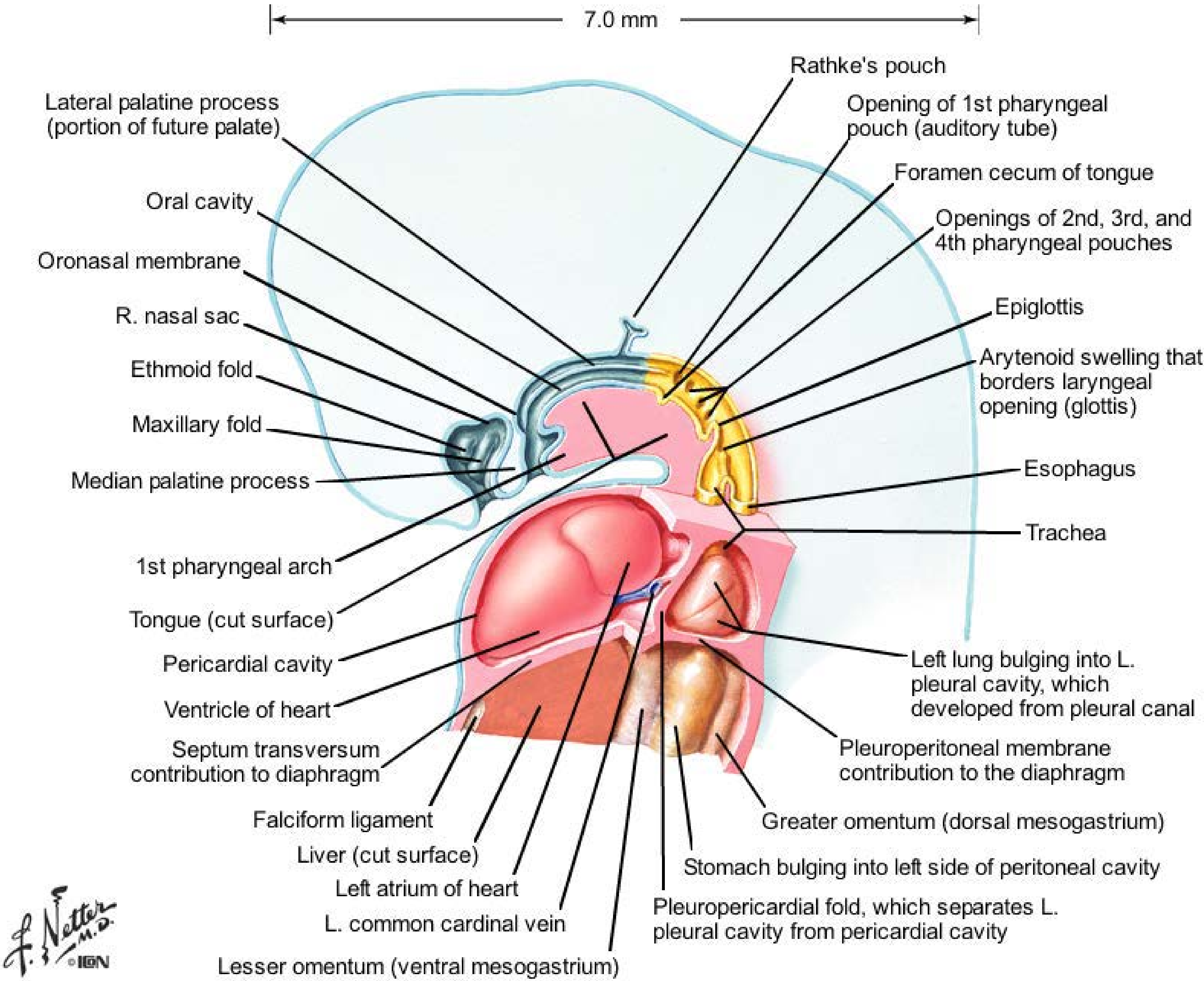
A. Cross section of embryo



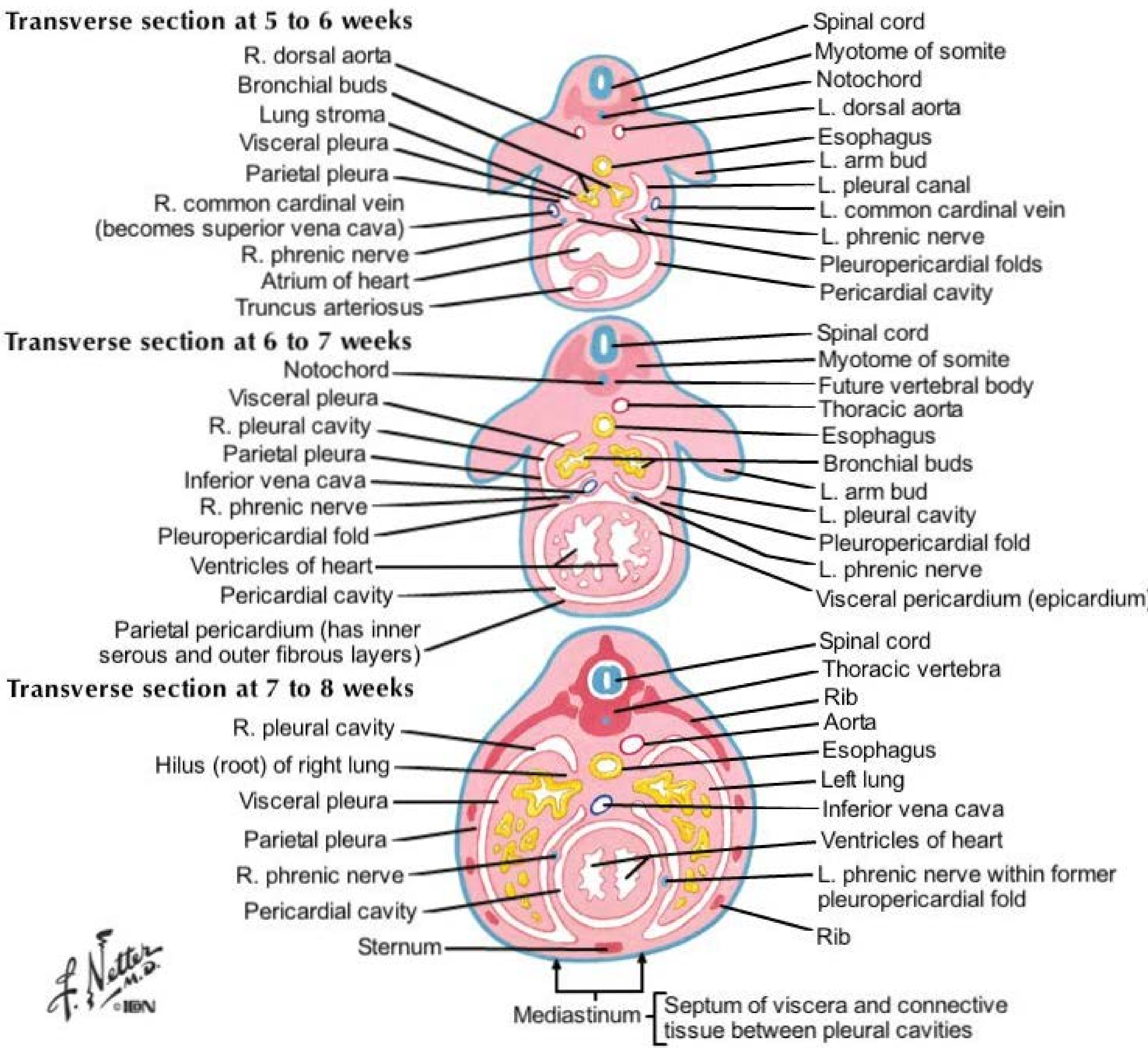
B. Sagittal section at 5 to 6 weeks



The Relationship Between Lungs and Pleural Cavities
Sagittal section at 6 to 7 weeks

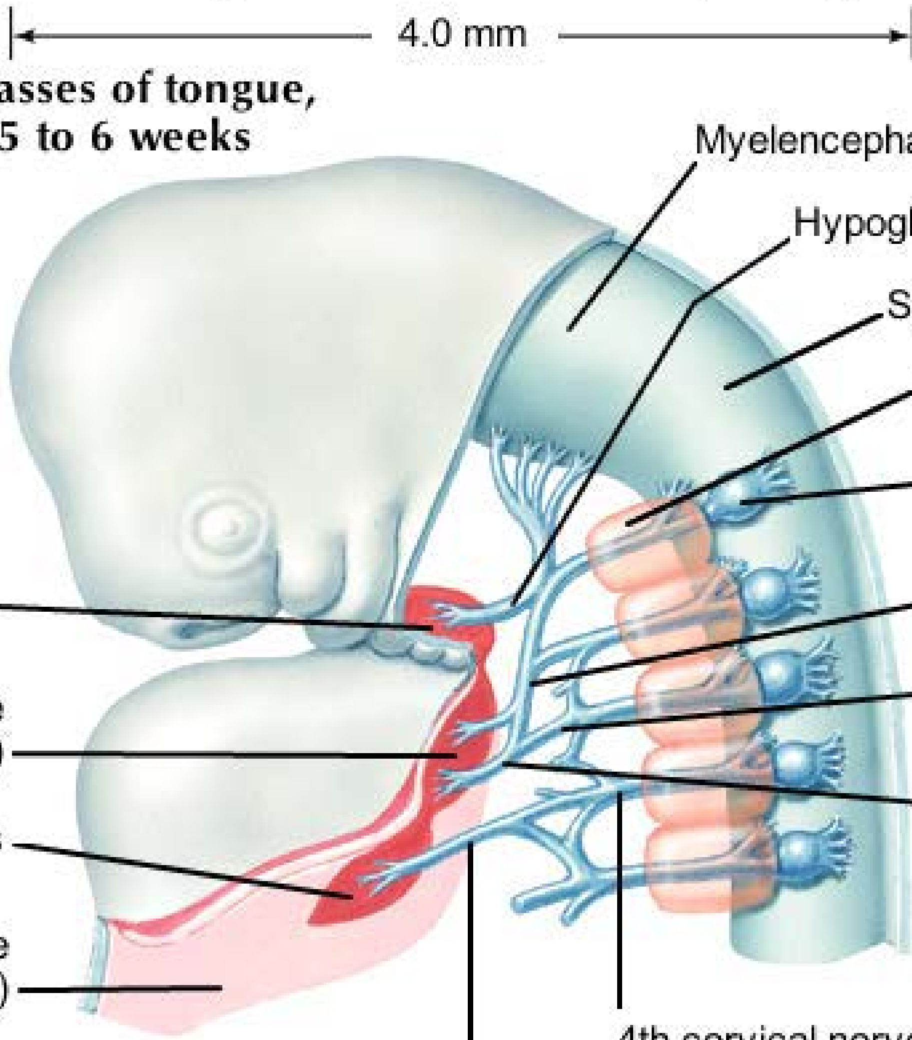


Visceral and Parietal Pleura

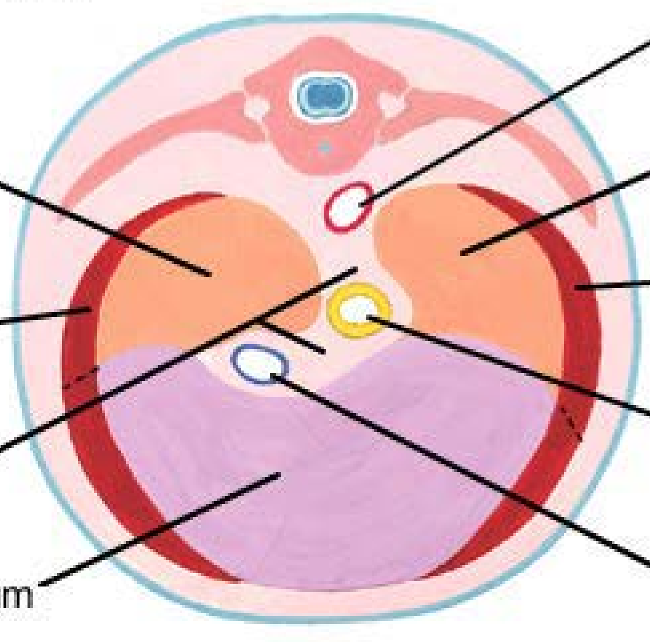


Development of the Diaphragm

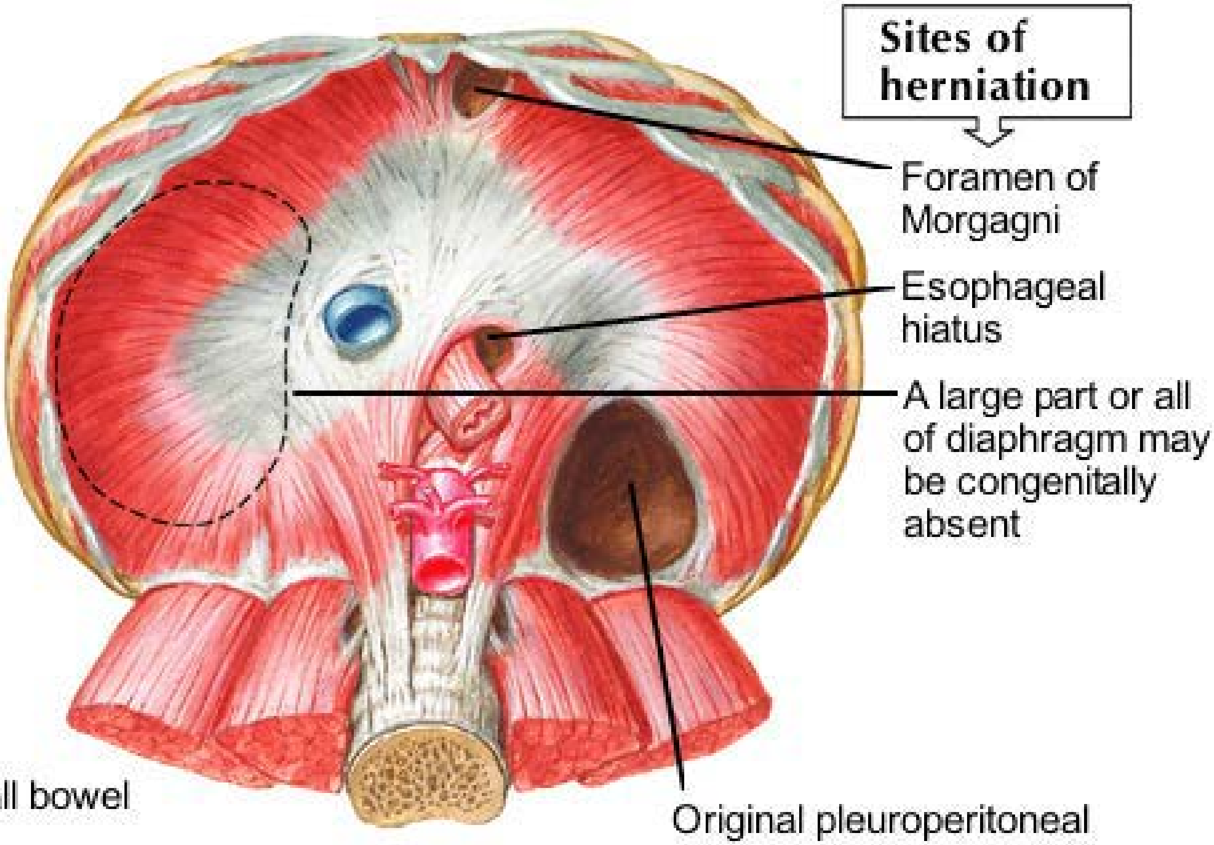
Innervation of muscle masses of tongue, neck, and diaphragm at 5 to 6 weeks

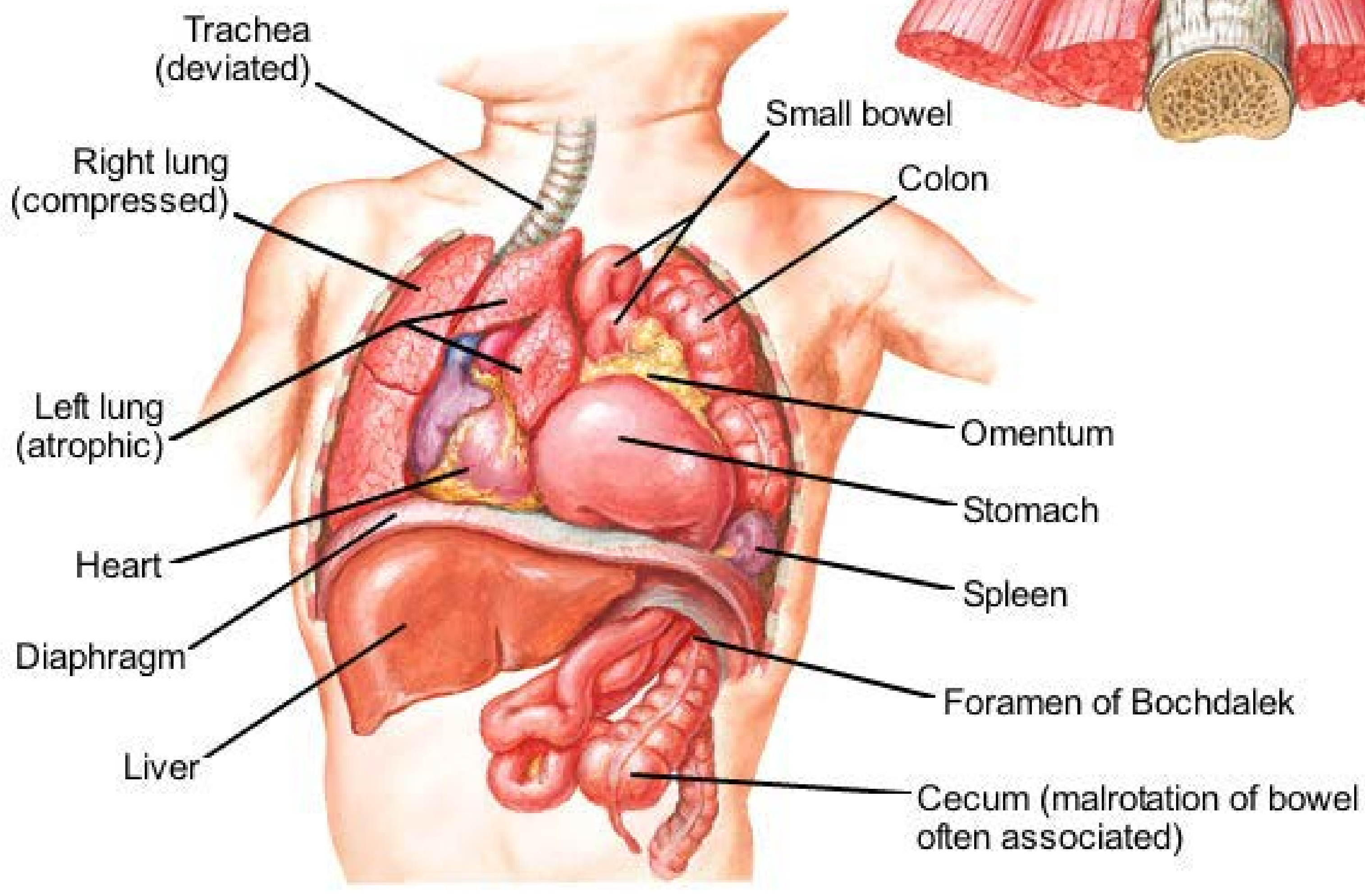


Embryological origins of diaphragm



Congenital Diaphragmatic Hernia





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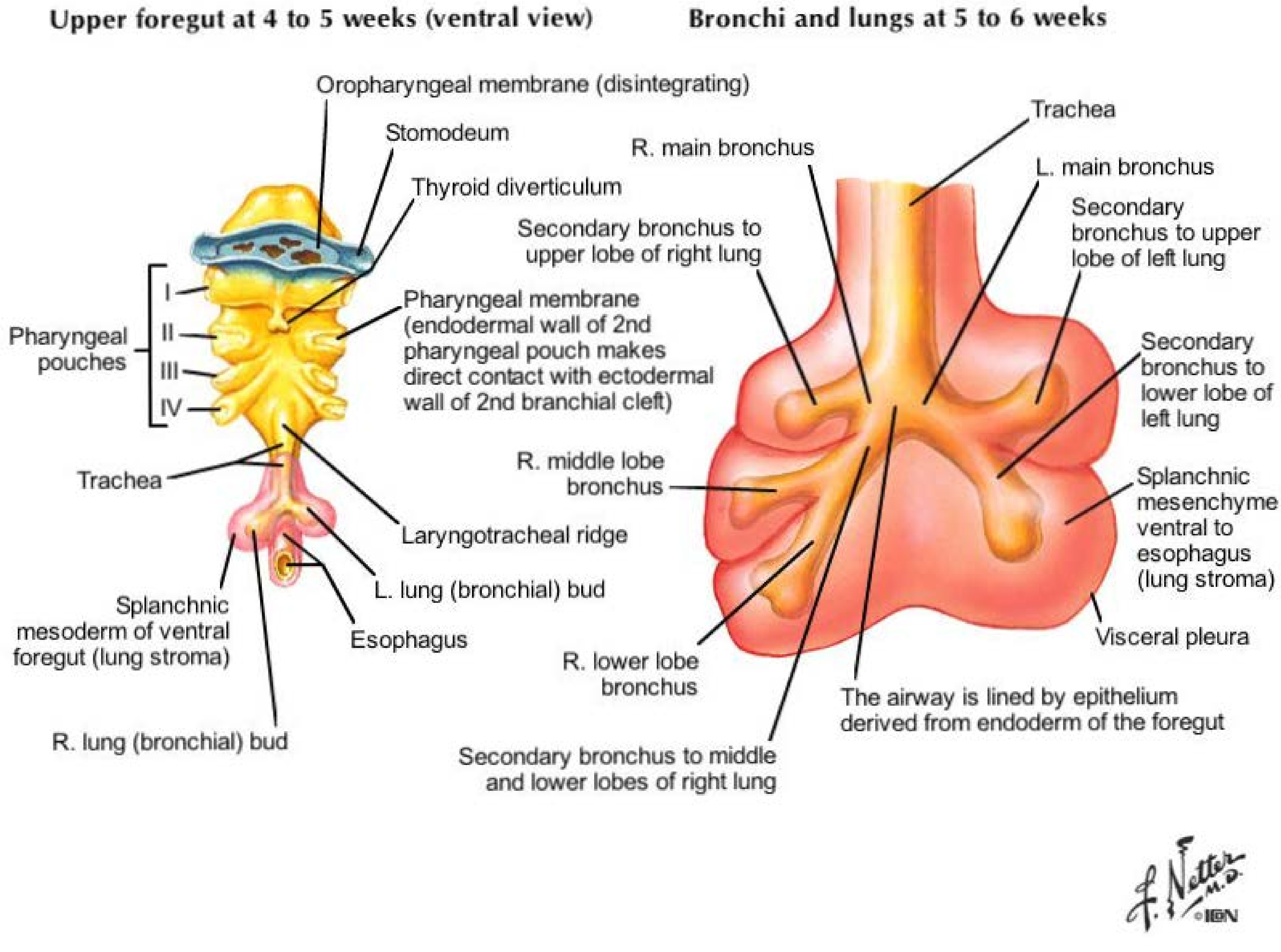
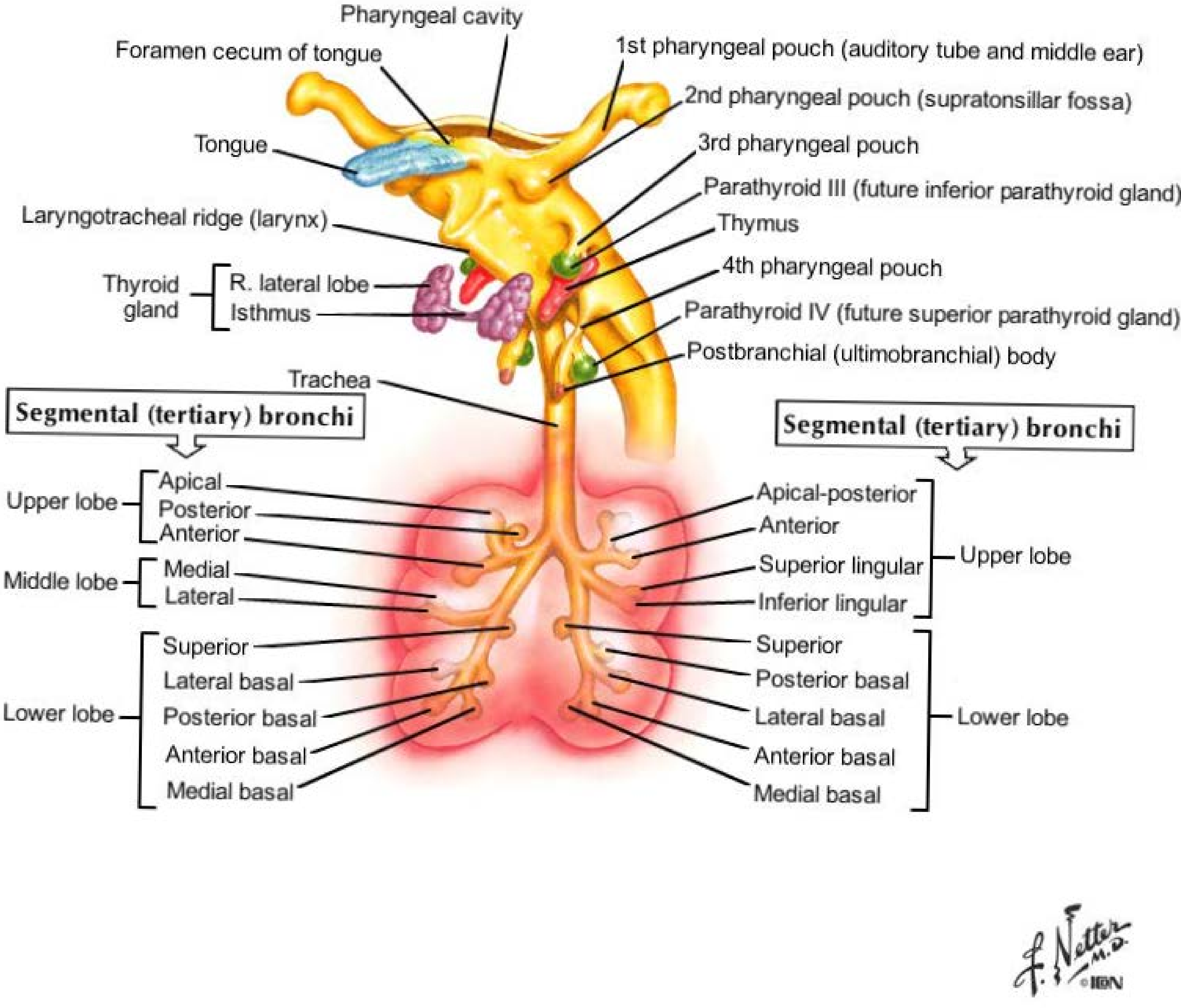
Airway Branching

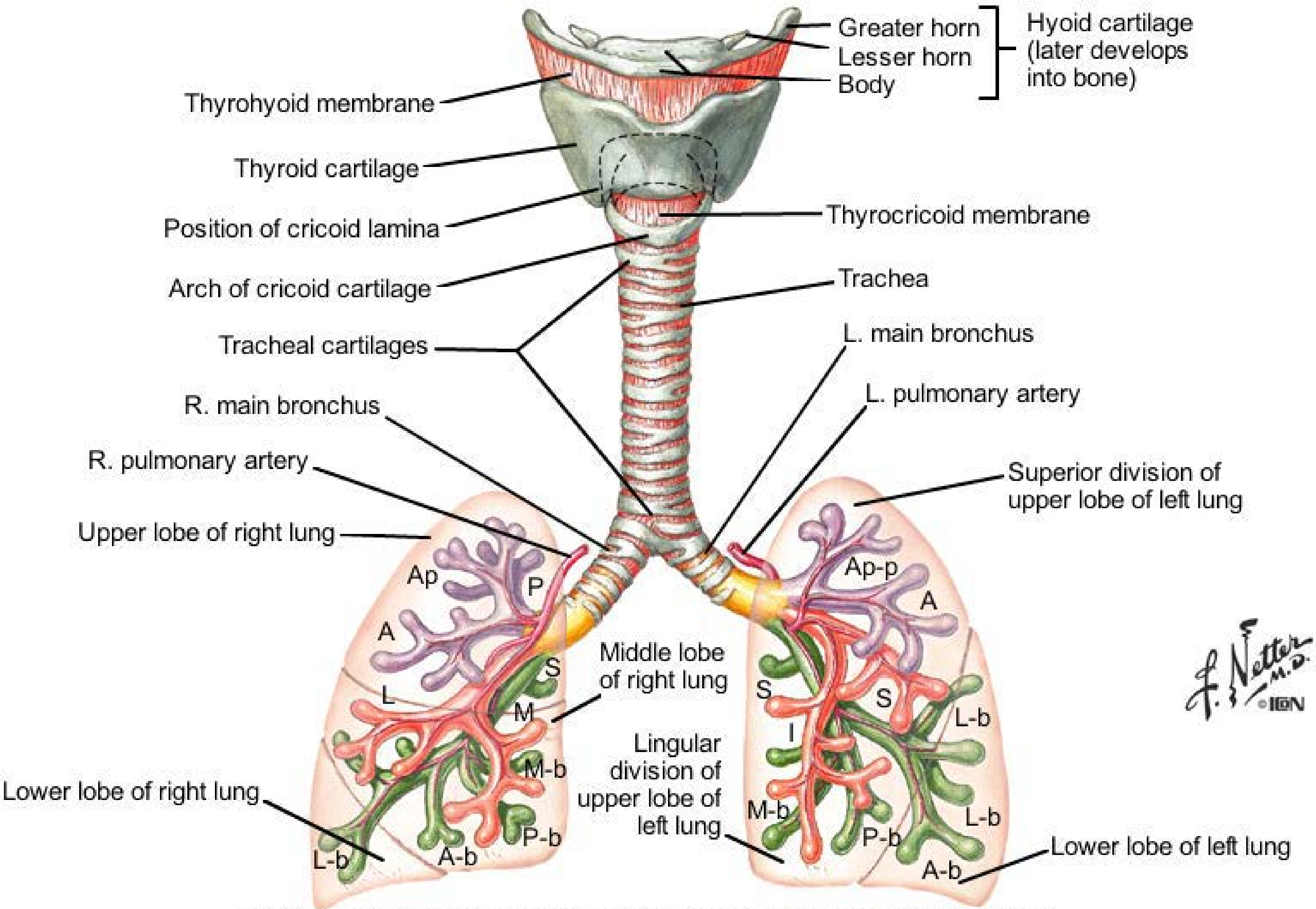


Airway Branching
Respiratory system at 6 to 7 weeks



Airway Branching

Larynx, Tracheobronchial Tree, and Lungs at 7 to 10 Weeks



Tertiary branches of bronchi to bronchopulmonary segments

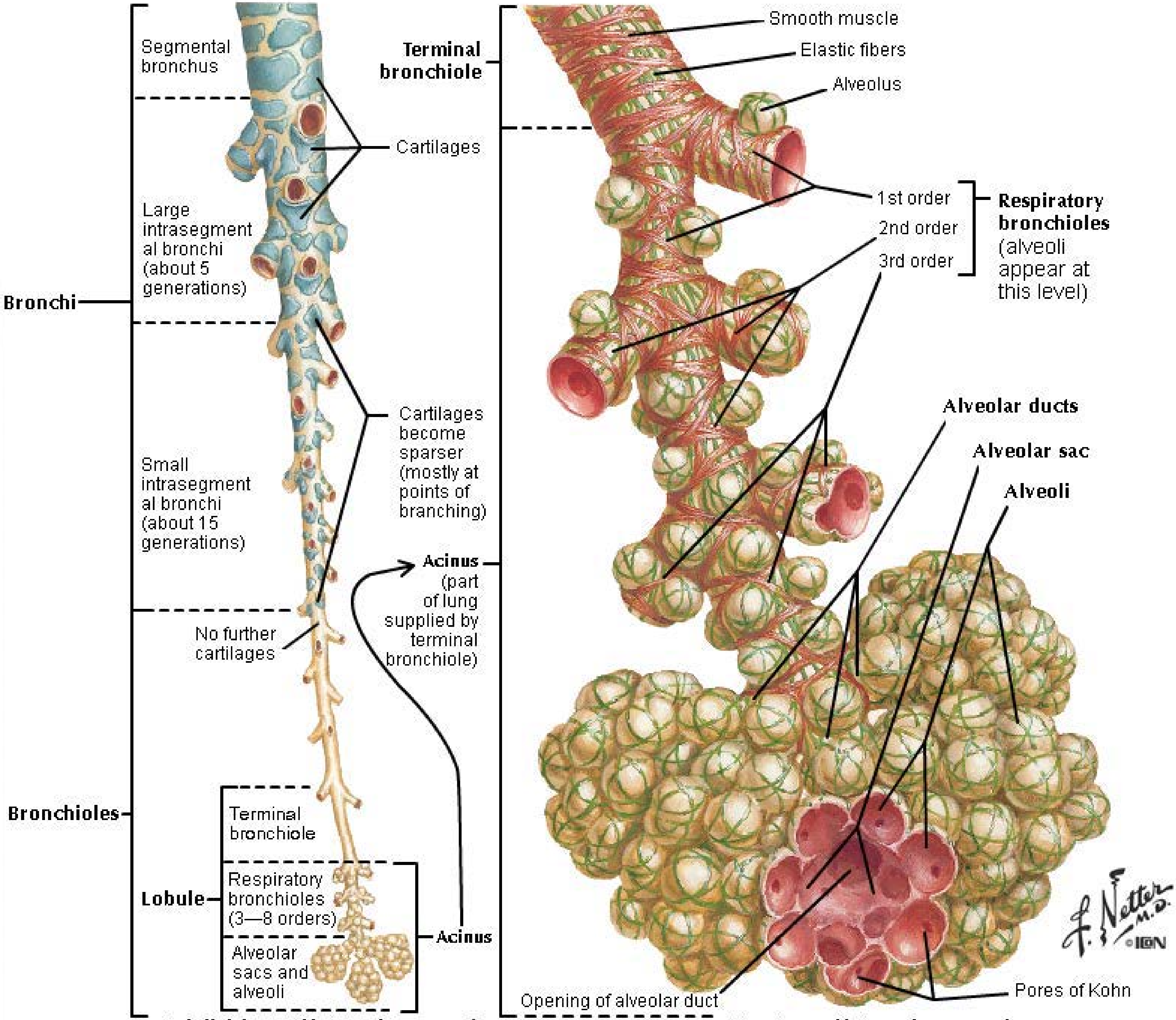
Right lung

- Upper lobe (purple) — Apical (Ap), posterior (P), anterior (A)
- Middle lobe (red) — Medial (M), lateral (L)
- Lower lobe (green) — Superior (S), anterior basal (A-b), posterior basal (P-b), medial basal (M-b), lateral basal (L-b)

Left lung

- Upper lobe
  - Superior division (purple) — Apical-posterior (Ap-p), Anterior (A)
  - Lingular division (red) — Superior (S), inferior (I)
- Lower lobe (green) — Superior (S), anterior basal (A-b), medial basal (M-b), posterior basal (P-b), lateral basal (L-b)

Airway Branching

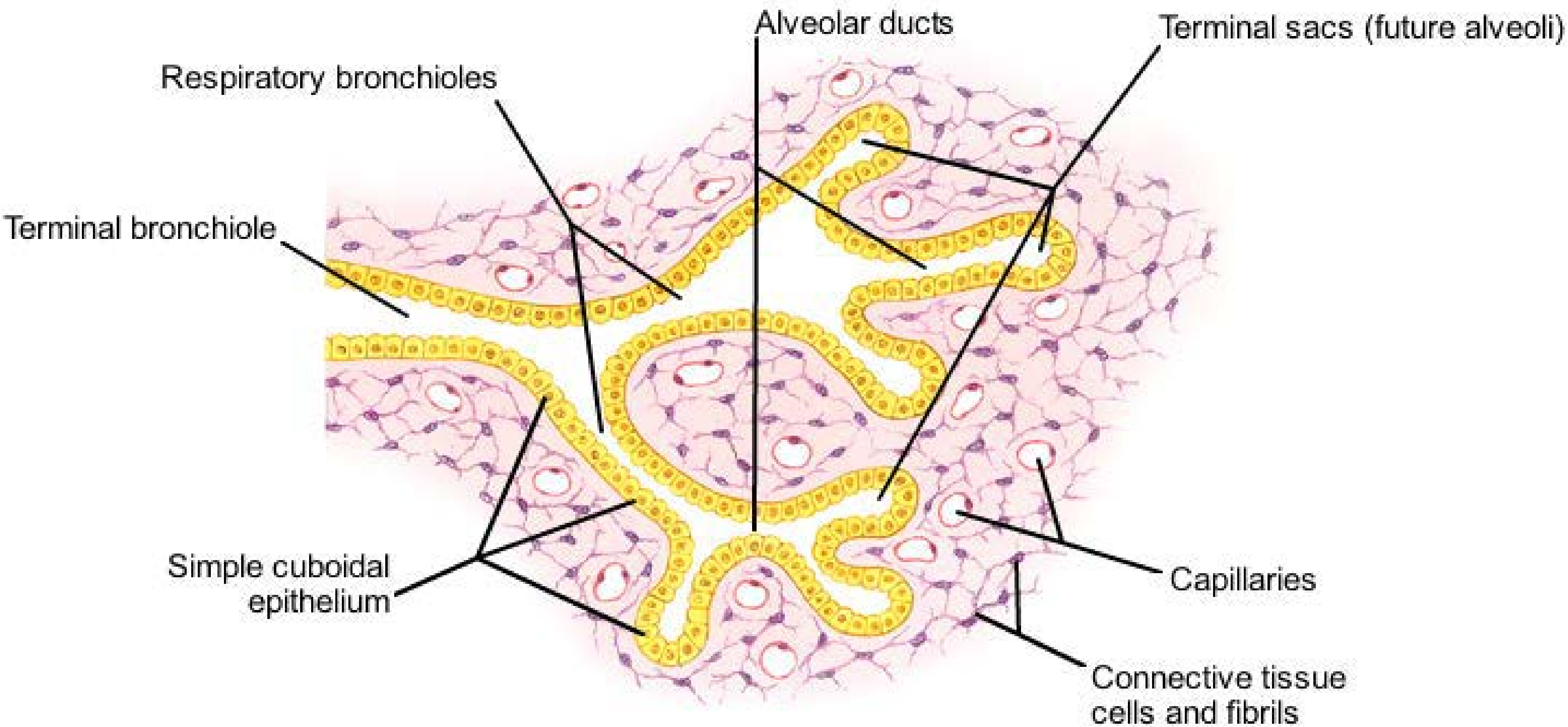


Subdivisions of intrapulmonary airways

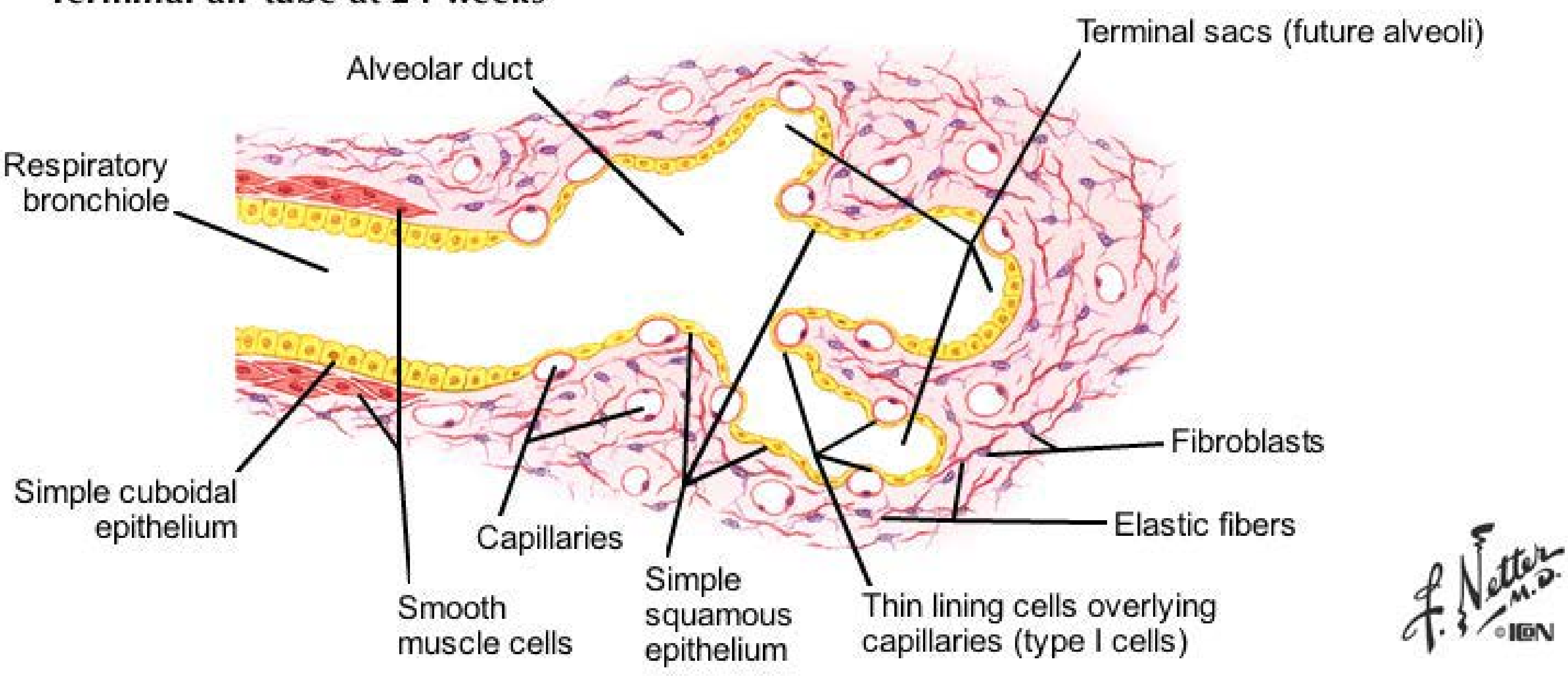
Structure of intrapulmonary airways

Bronchial Epithelium Maturation

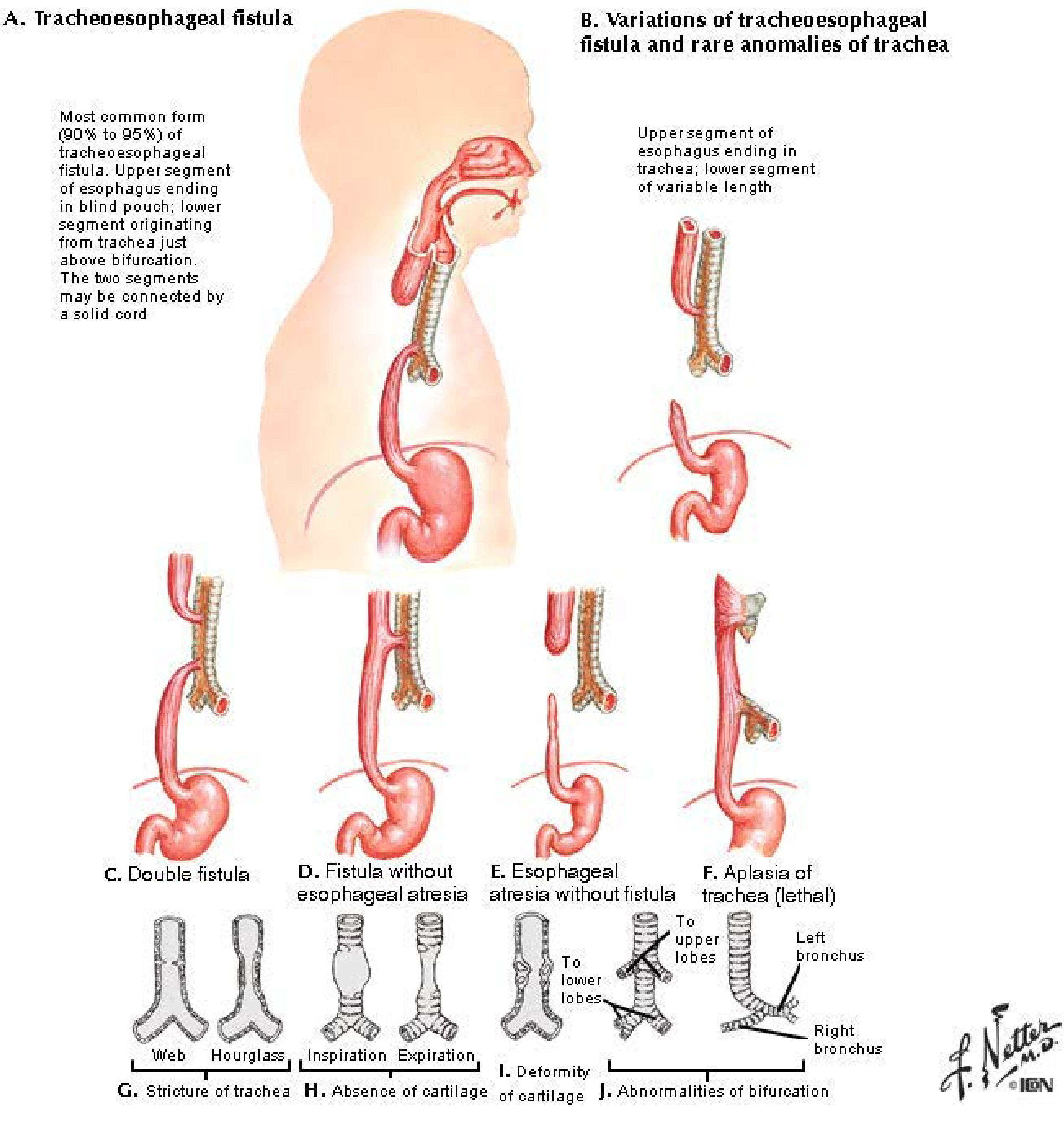
Terminal air tube at 20 weeks



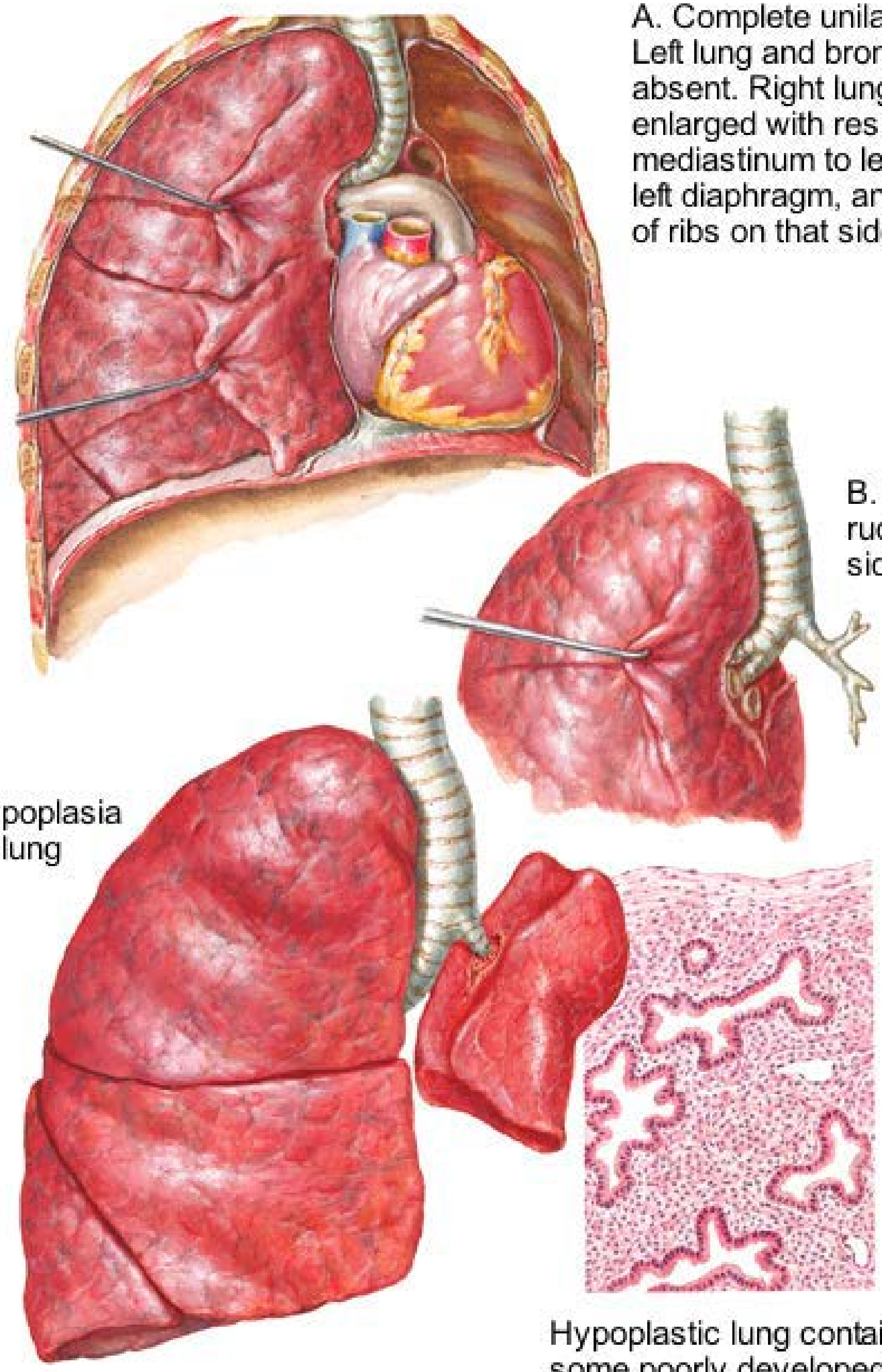
Terminal air tube at 24 weeks



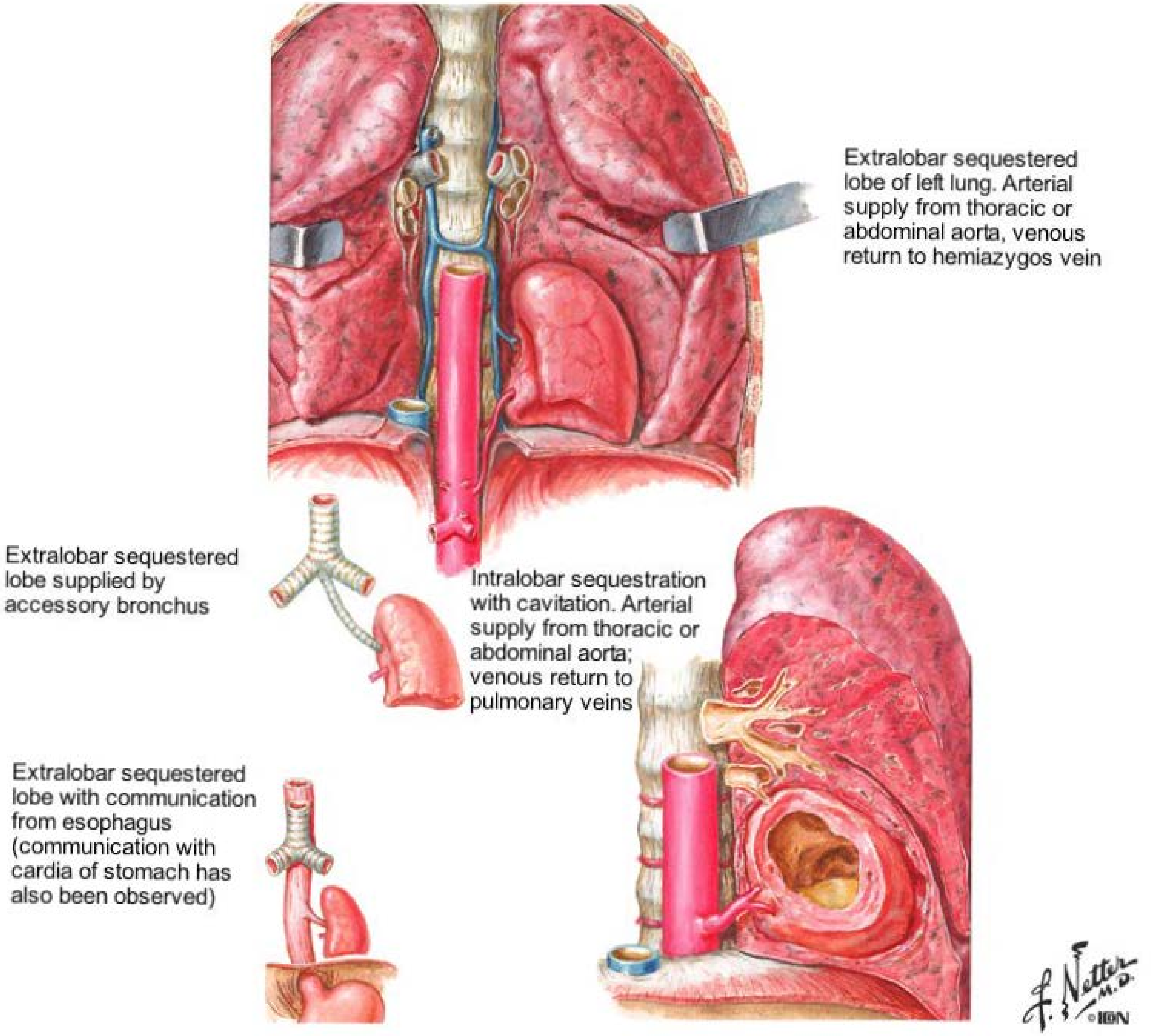
Congenital Anomalies of the Lower Airway



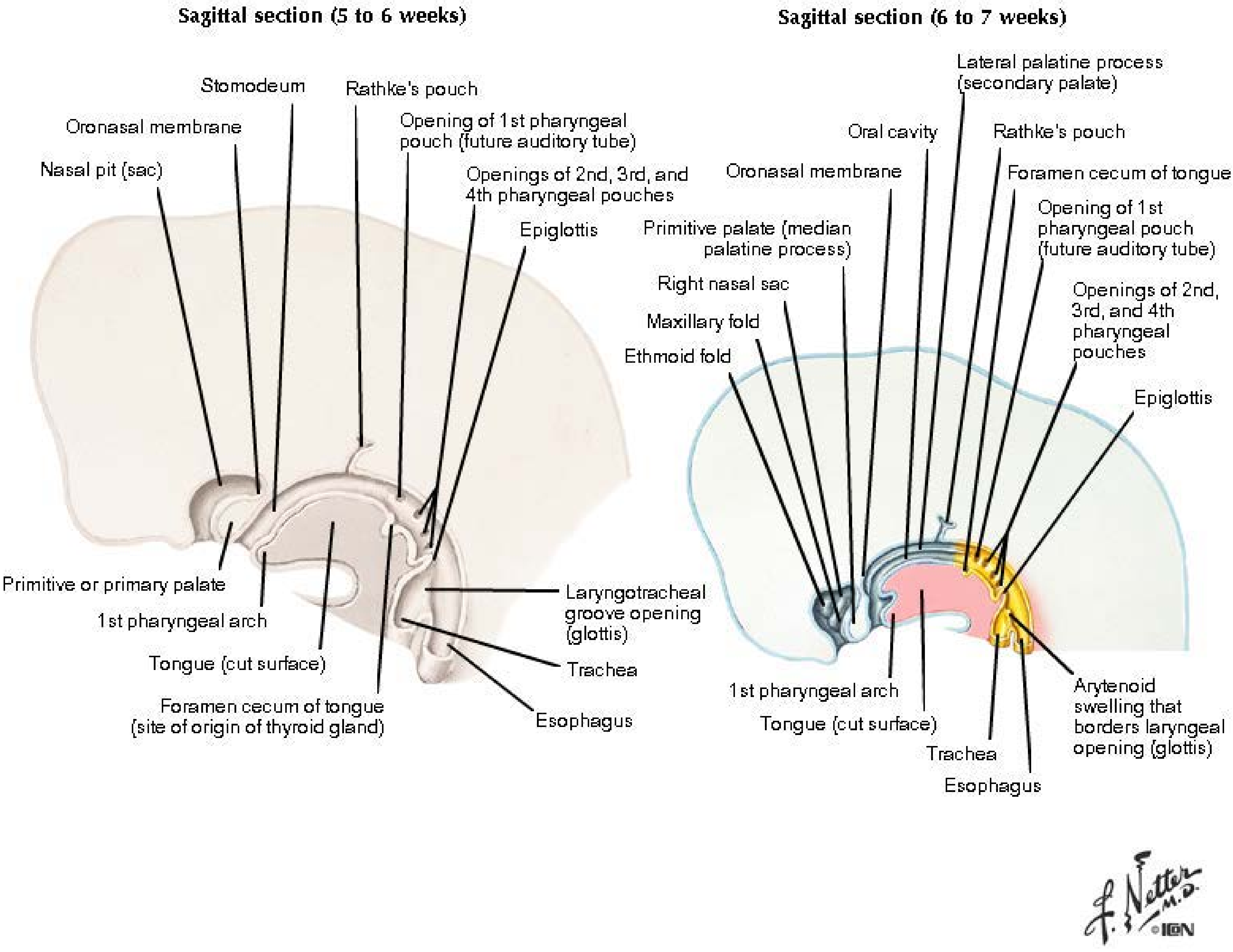
Airway Branching Anomalies
Pulmonary agenesis, aplasia, and hypoplasia



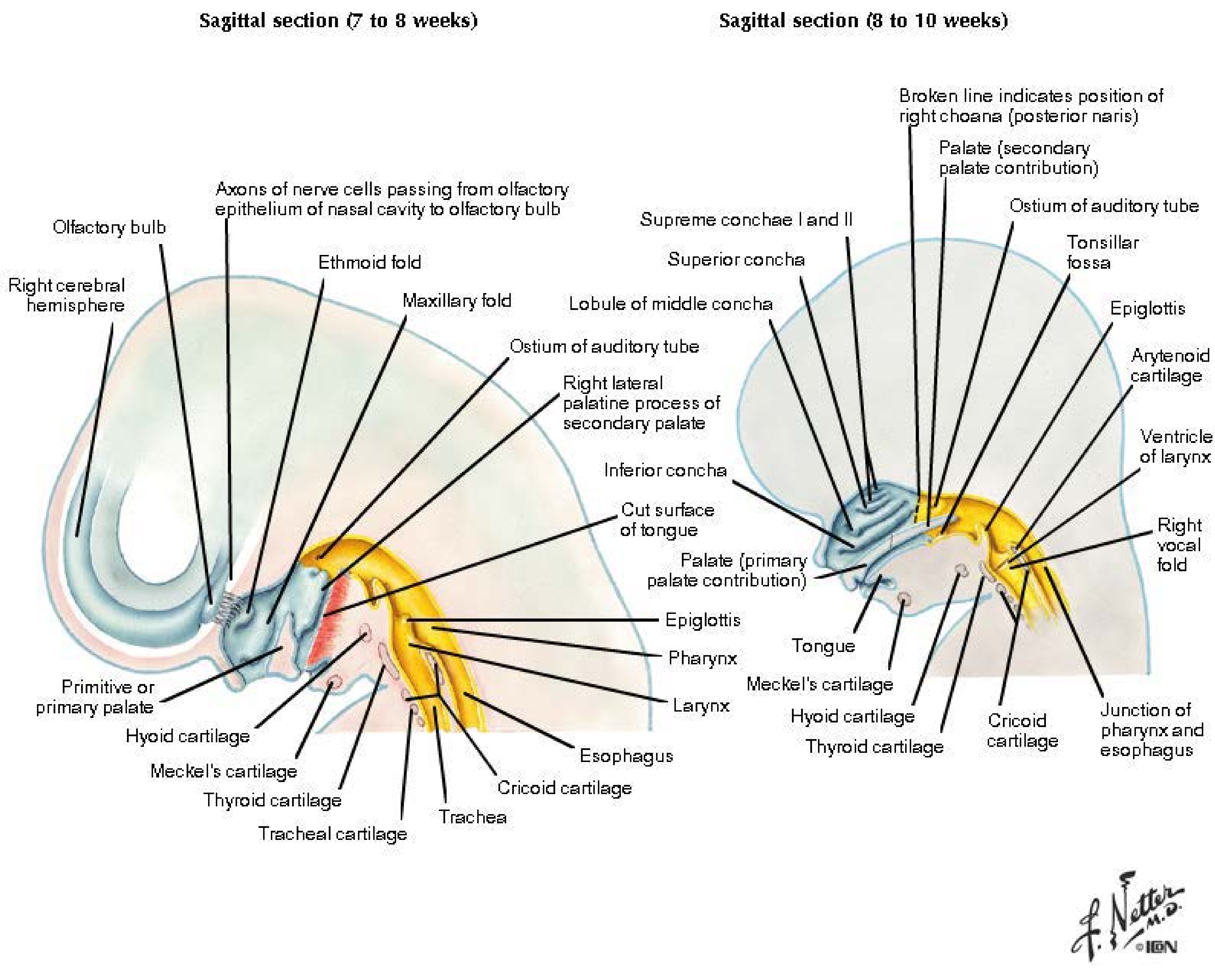
Bronchopulmonary Sequestration



Palate Formation in the Upper Airway



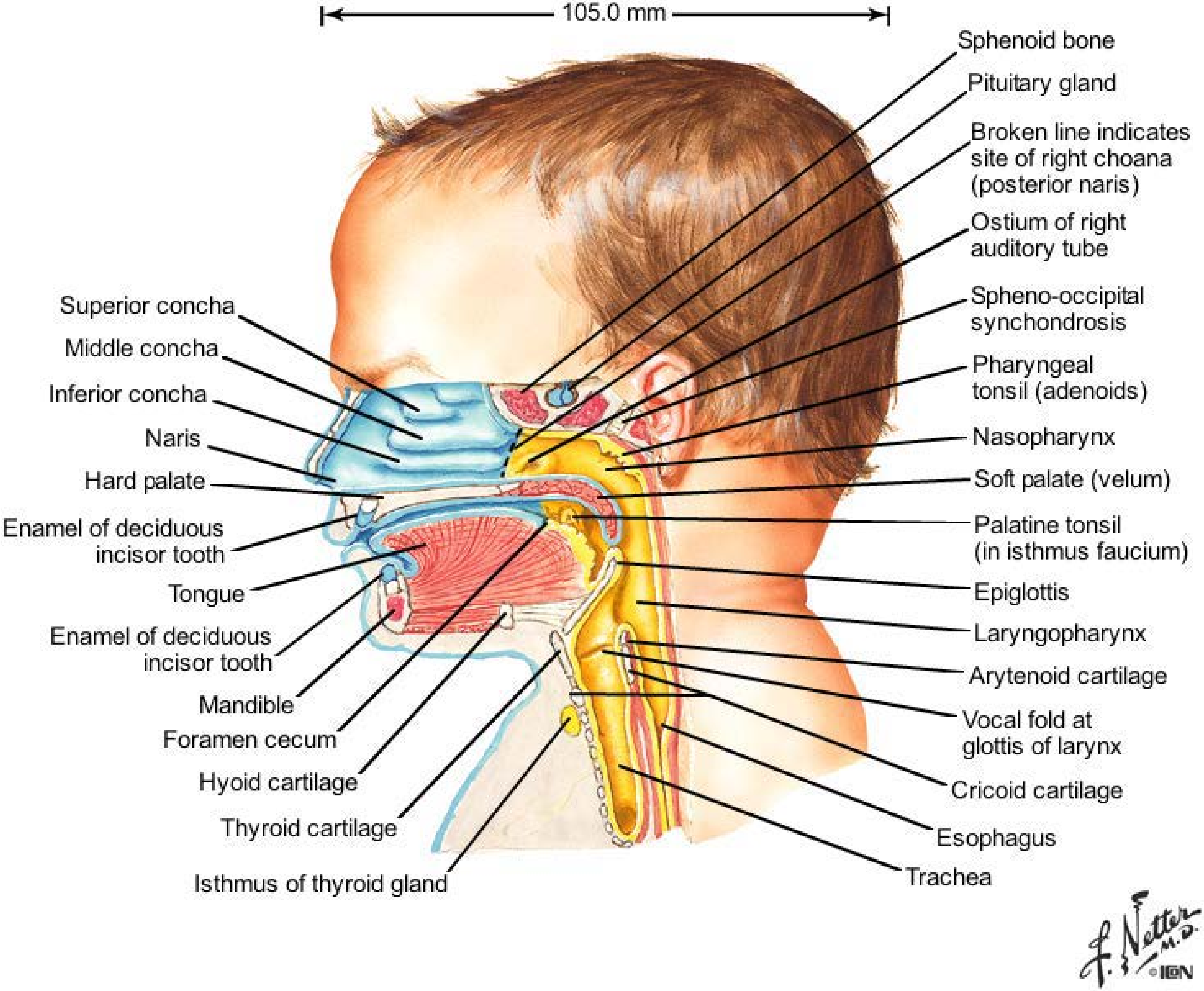
Palate Formation in the Upper Airway



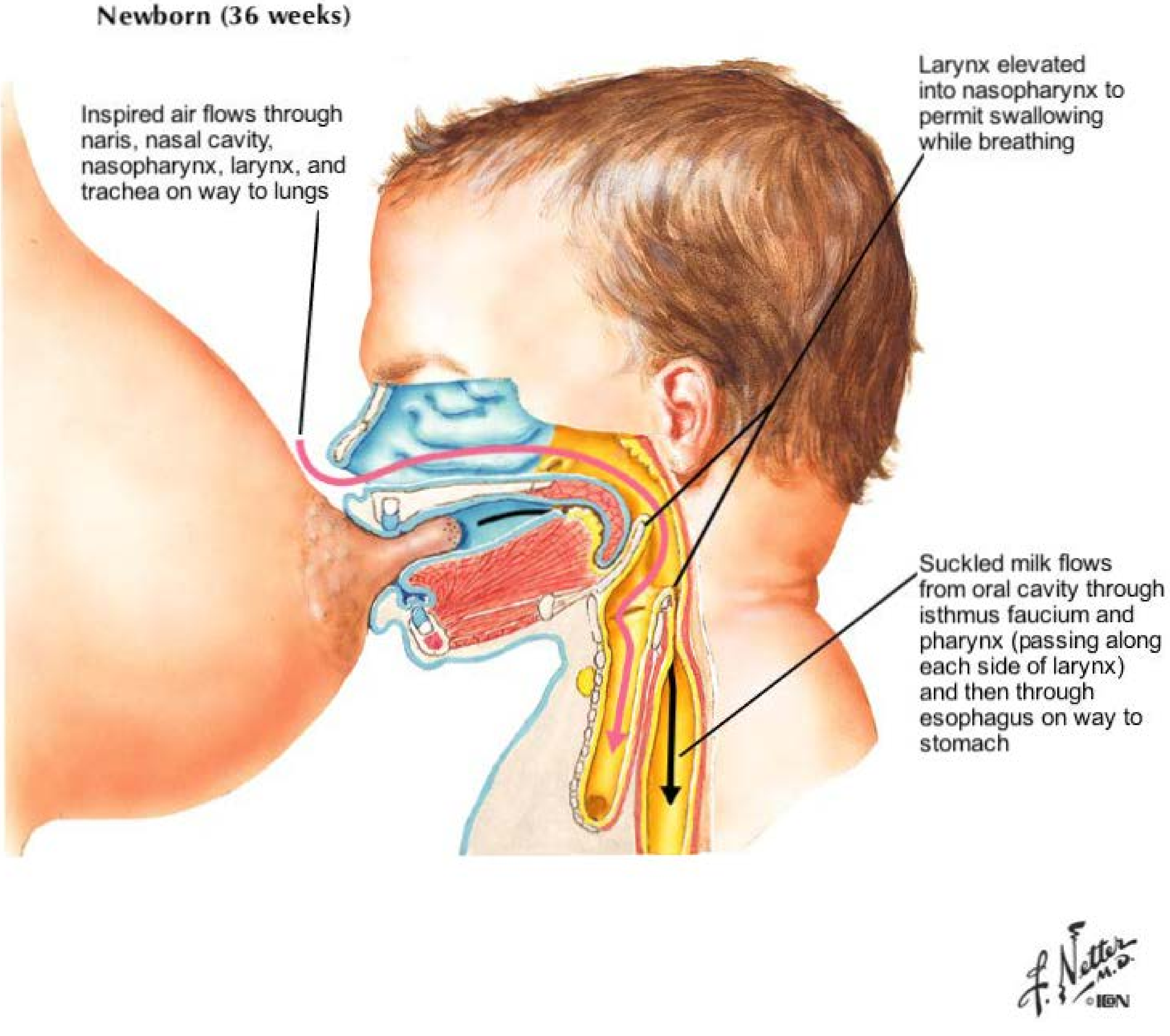
The Newborn Upper Airway

During quiet respiration with mouth closed (partial midsagittal section with nasal septum removed)

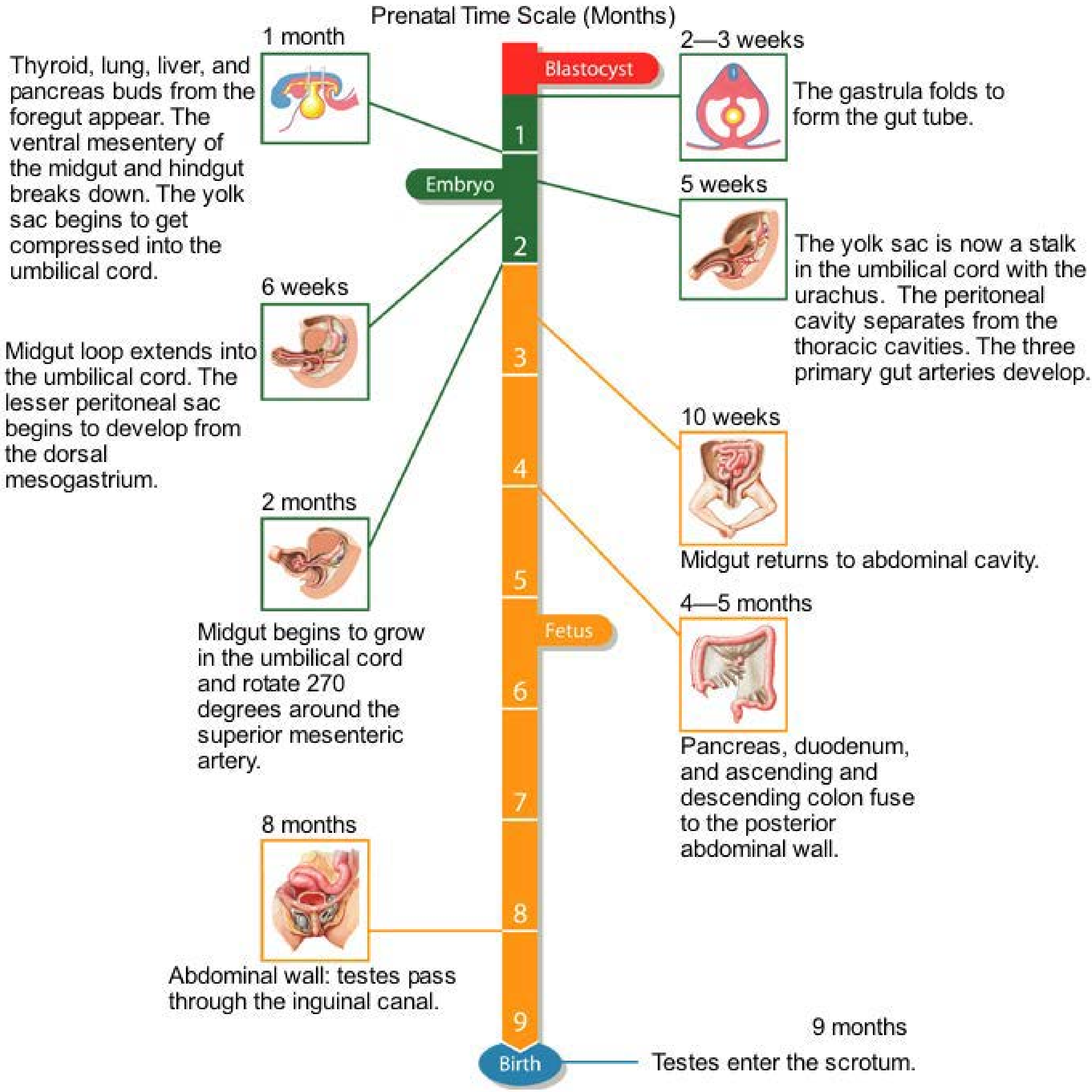
Newborn (36 weeks)



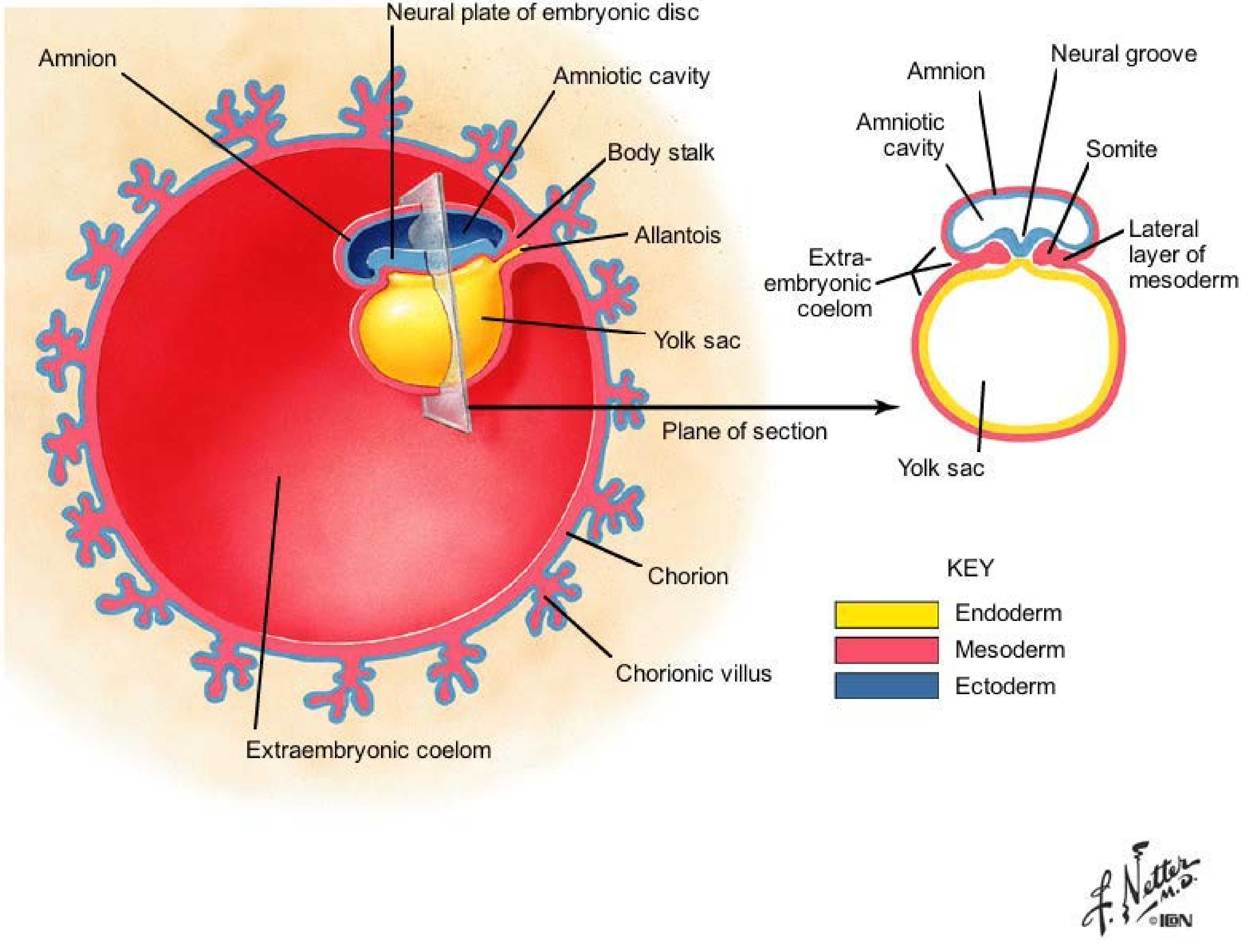
The Newborn Upper Airway
During nursing



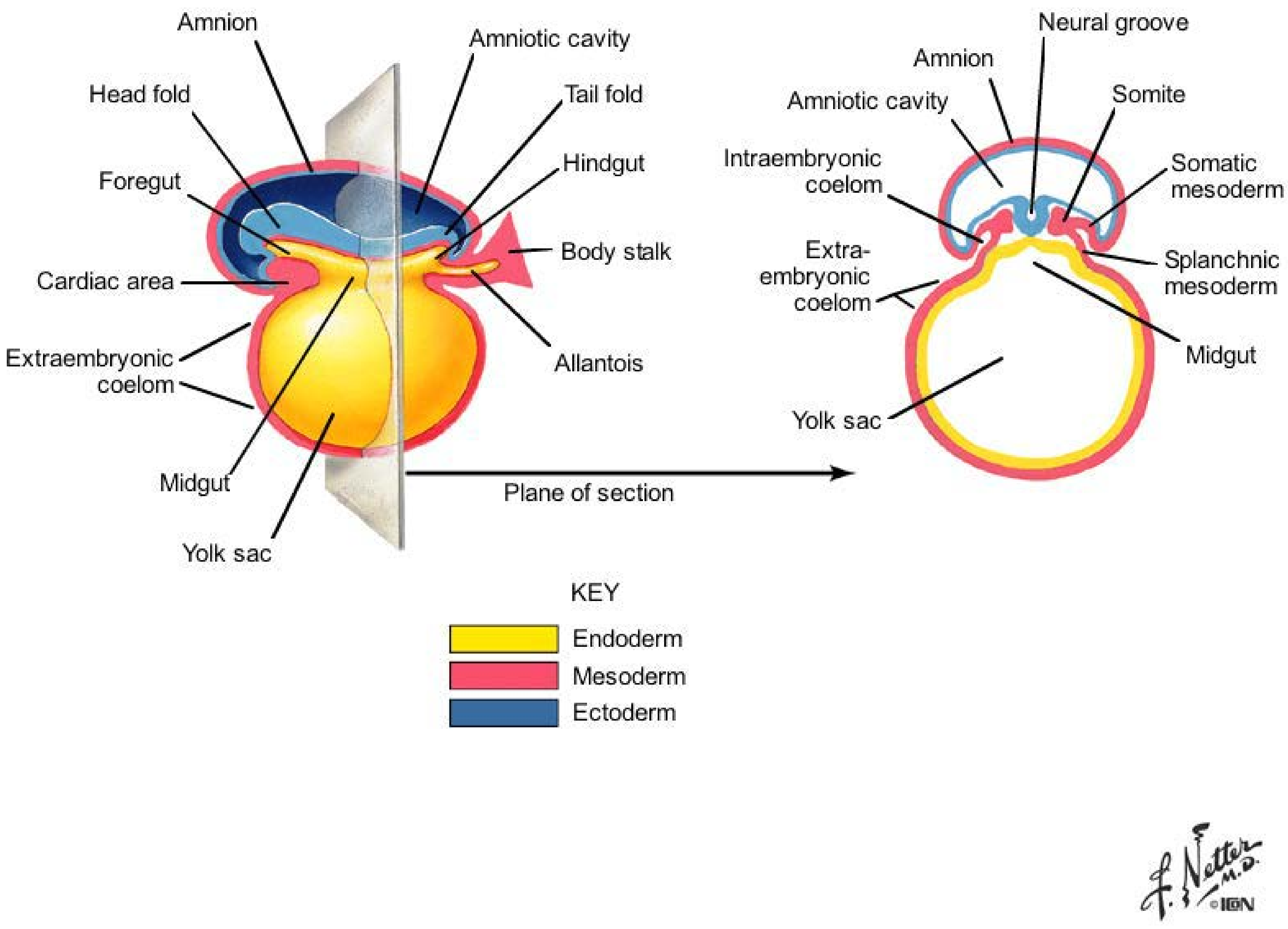
THE GASTROINTESTINAL SYSTEM AND ABDOMINAL WALL
TIMELINE



Early Primordia
14 days

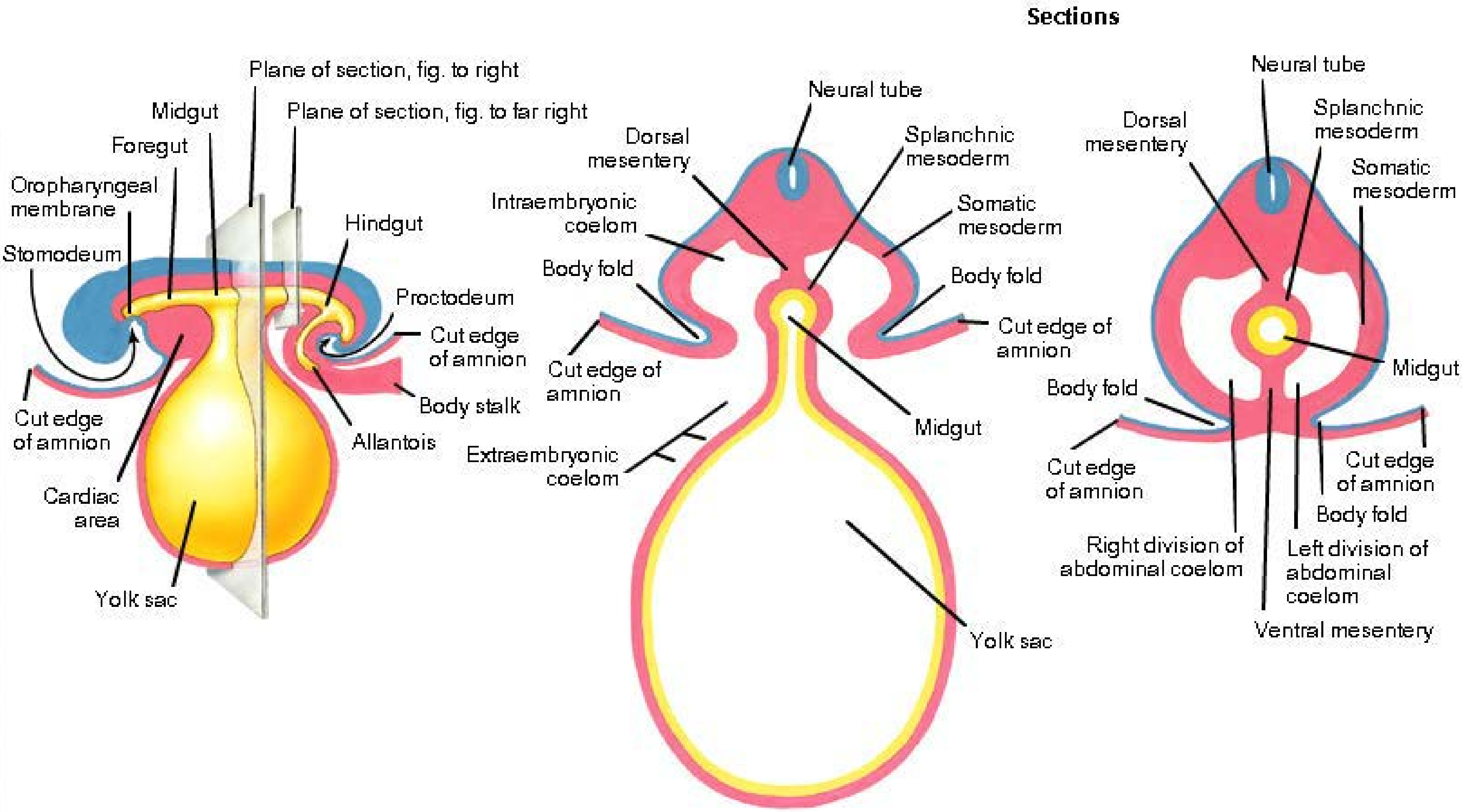


Early Primordia
16 days

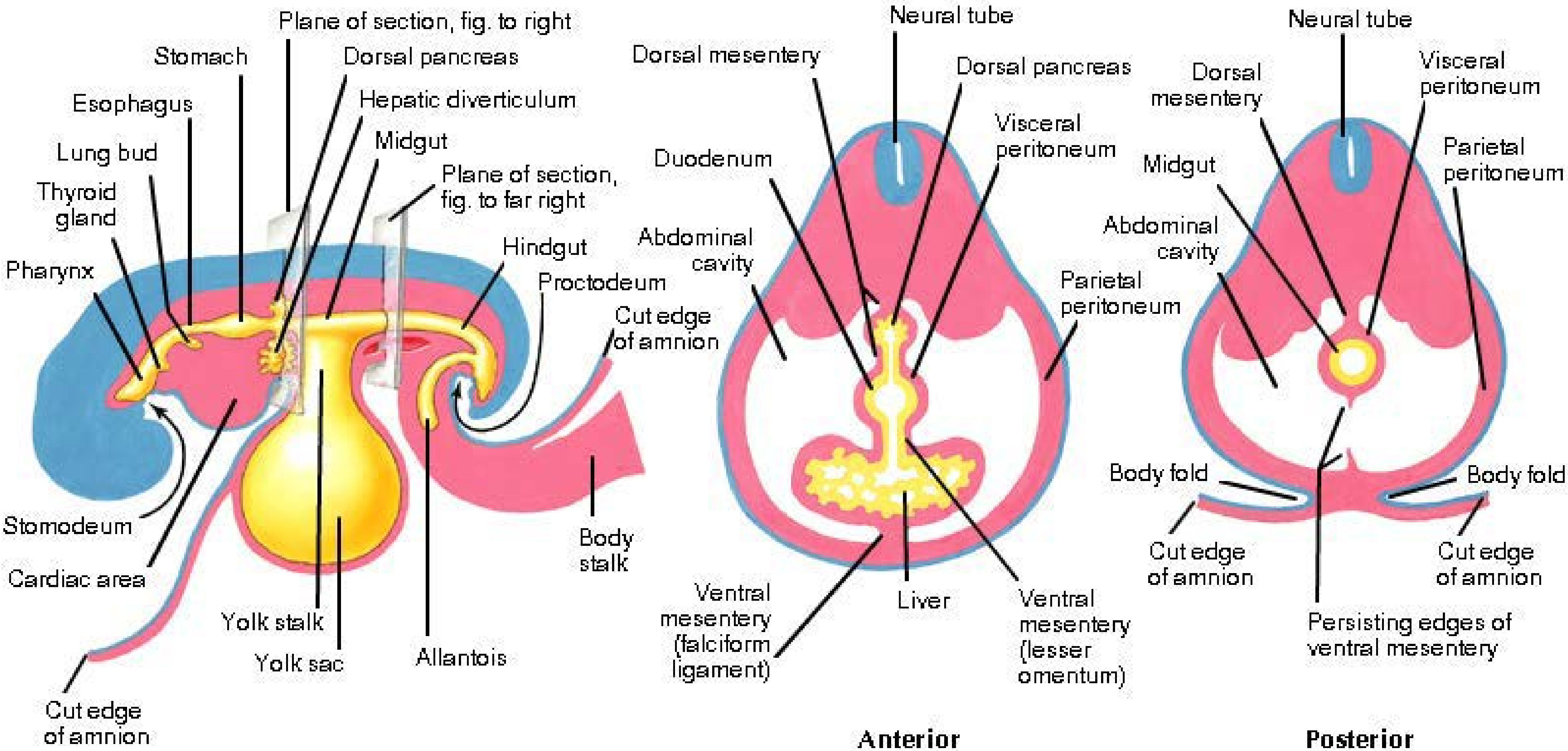


Formation of the Gut Tube and Mesenteries

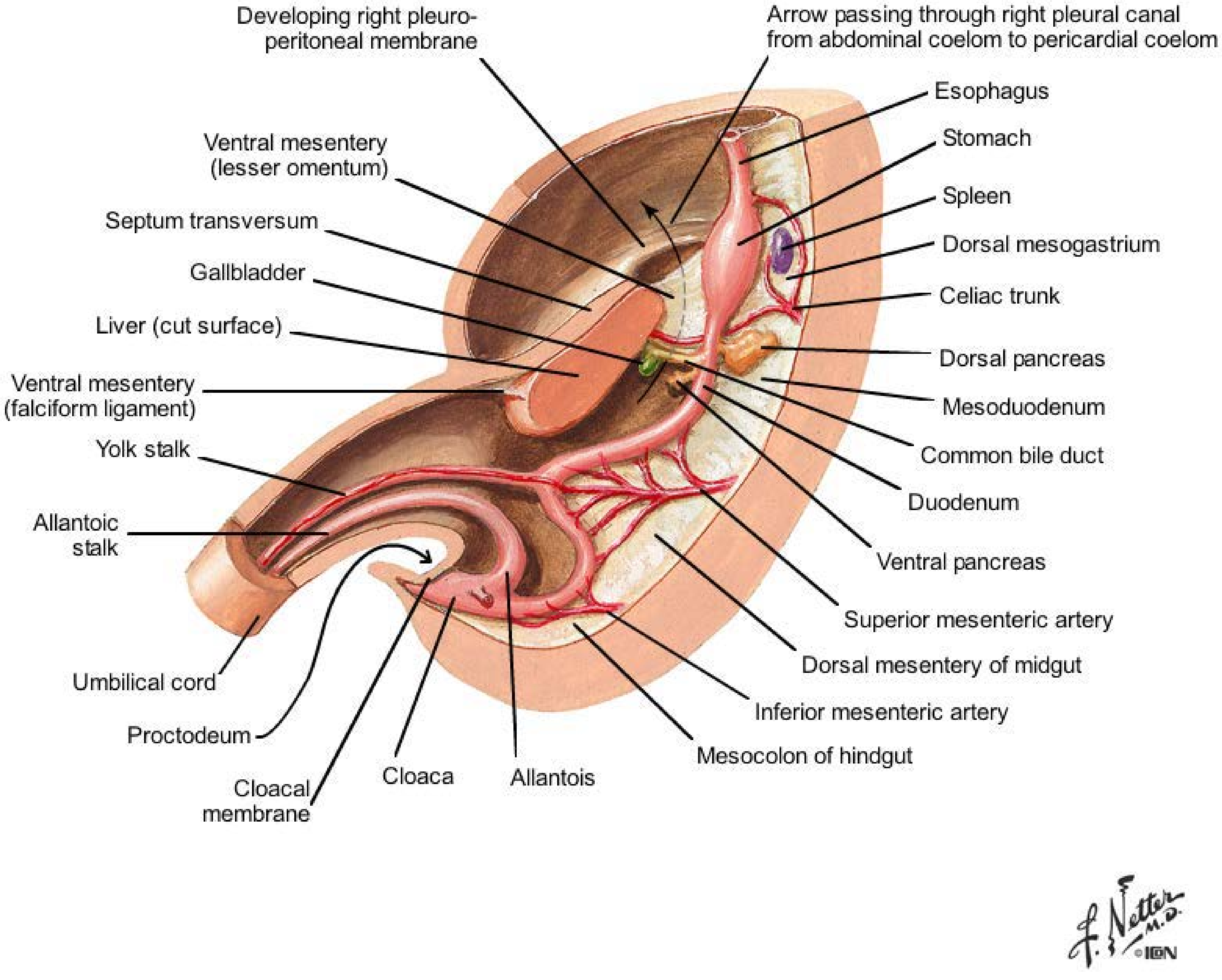
18 days



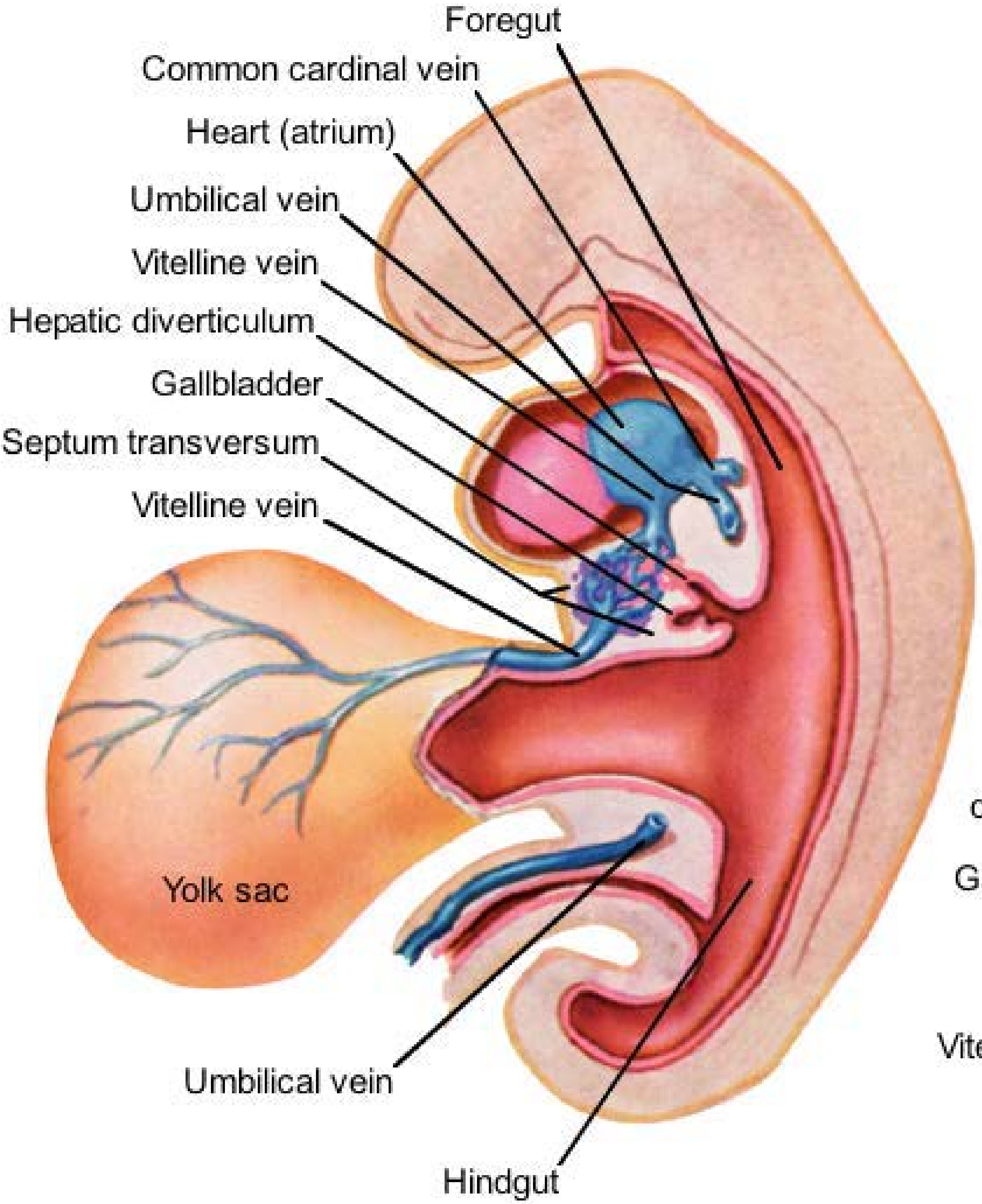
Formation of the Gut Tube and Mesenteries
1 month

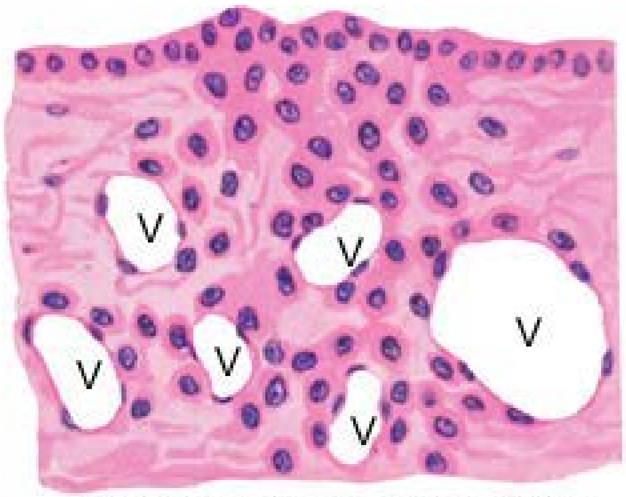


Foregut, Midgut, and Hindgut
5 weeks

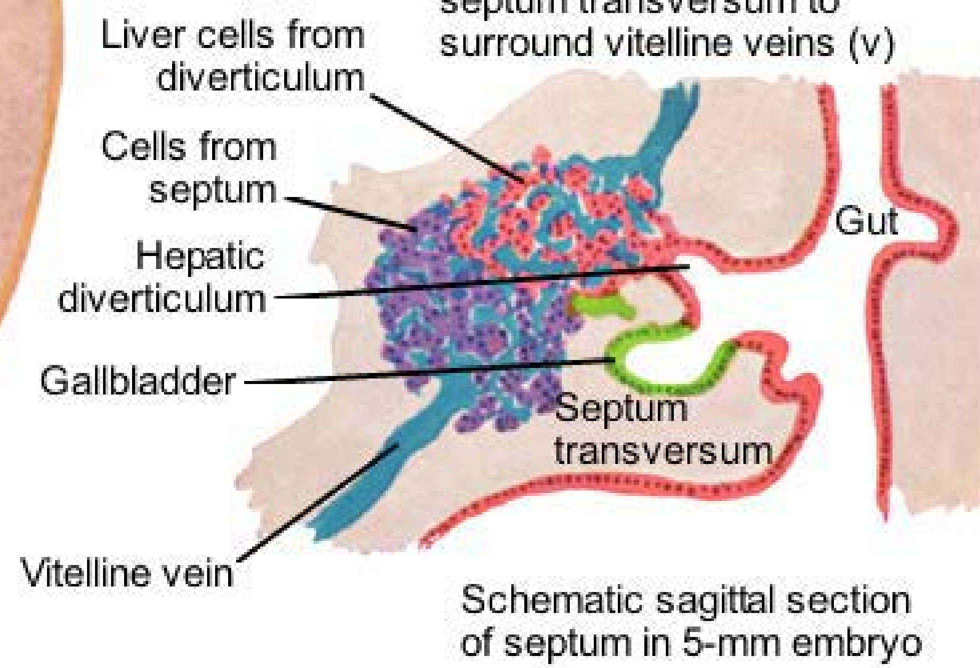


Abdominal Veins
Hepatic diverticulum in embryo of about 4 mm



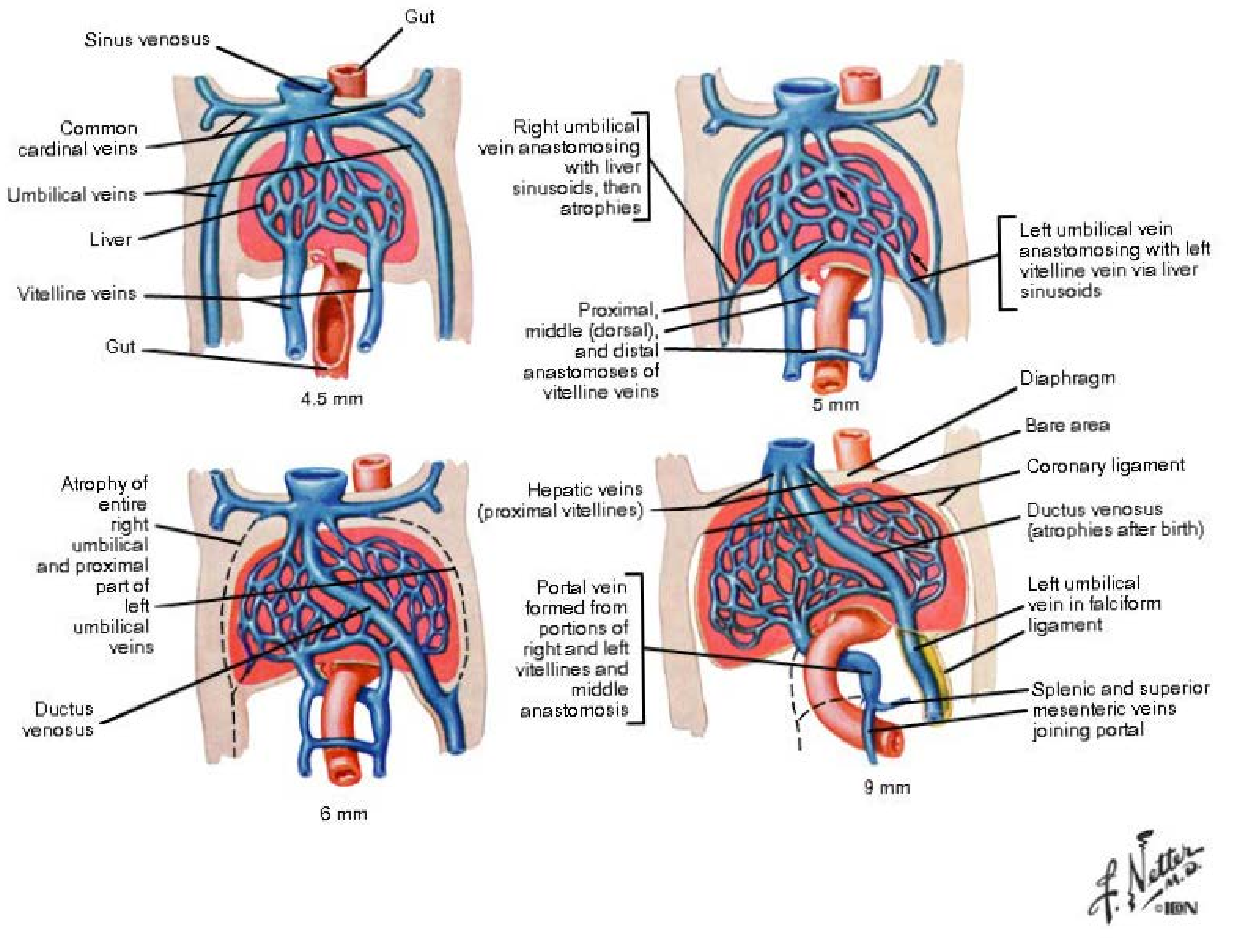


Endodermal cells penetrating septum transversum to surround vitelline veins (v)

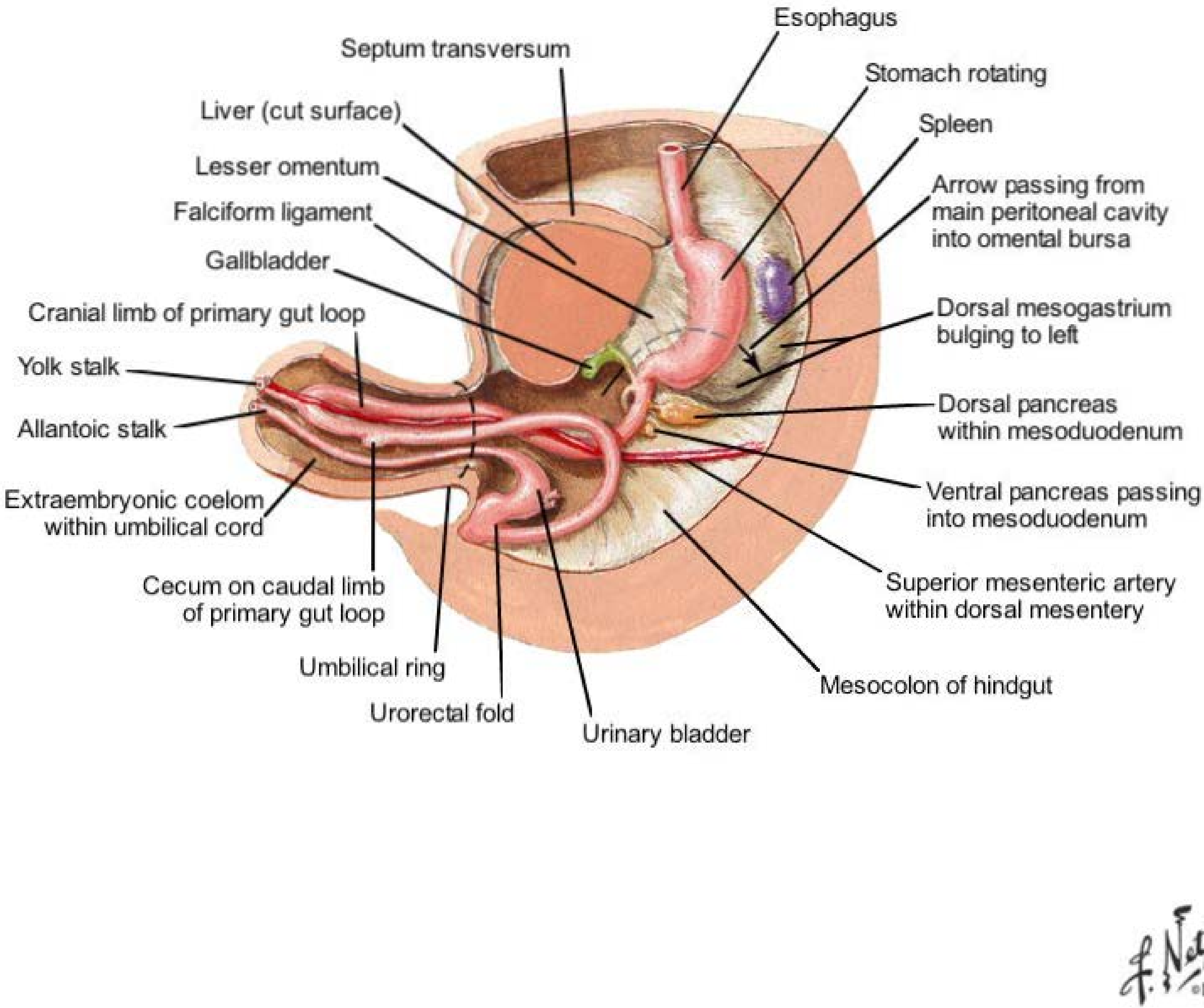


Schematic sagittal section of septum in 5-mm embryo

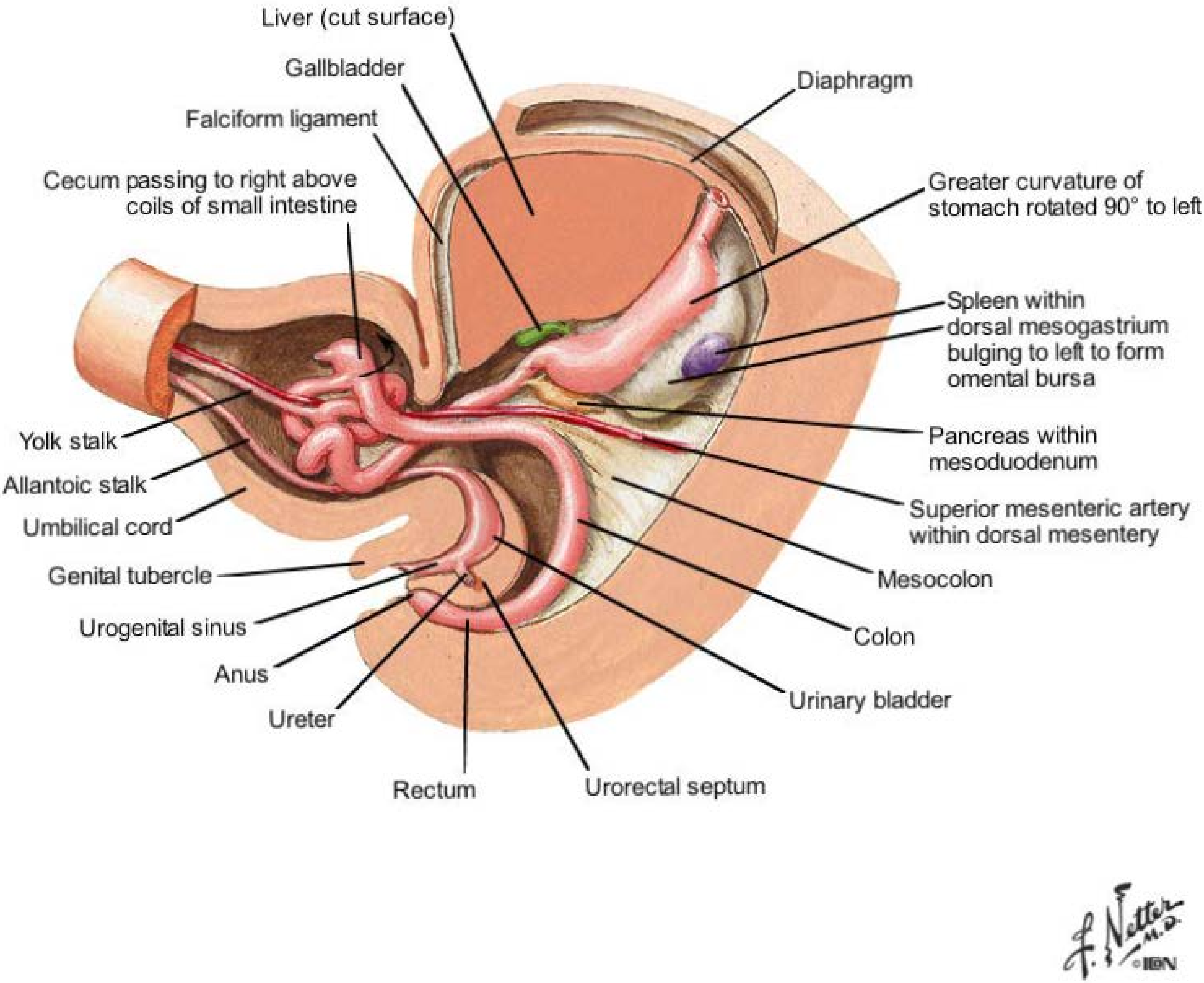
Abdominal Veins
Development of liver veins



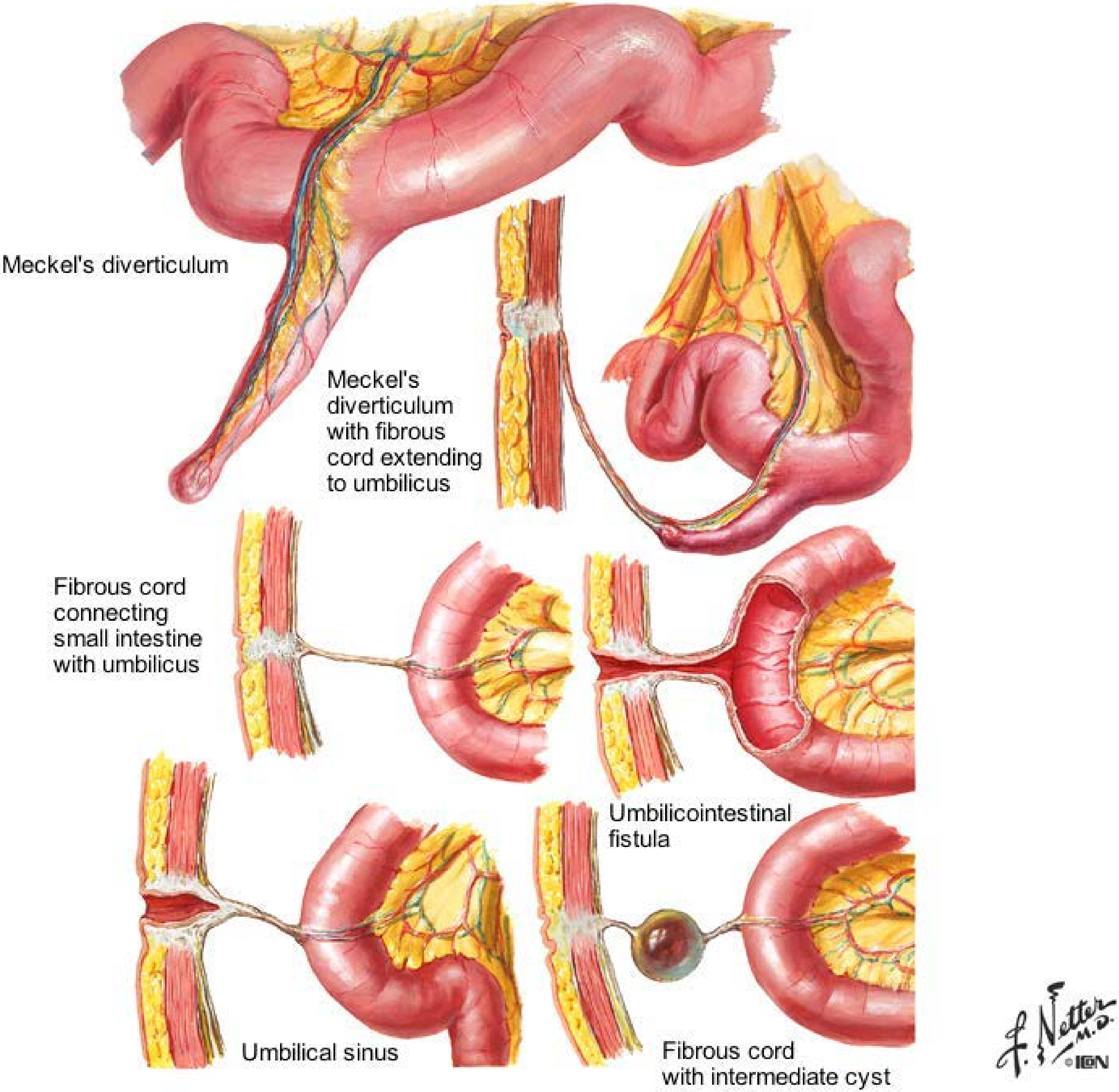
Foregut and Midgut Rotations
6 weeks



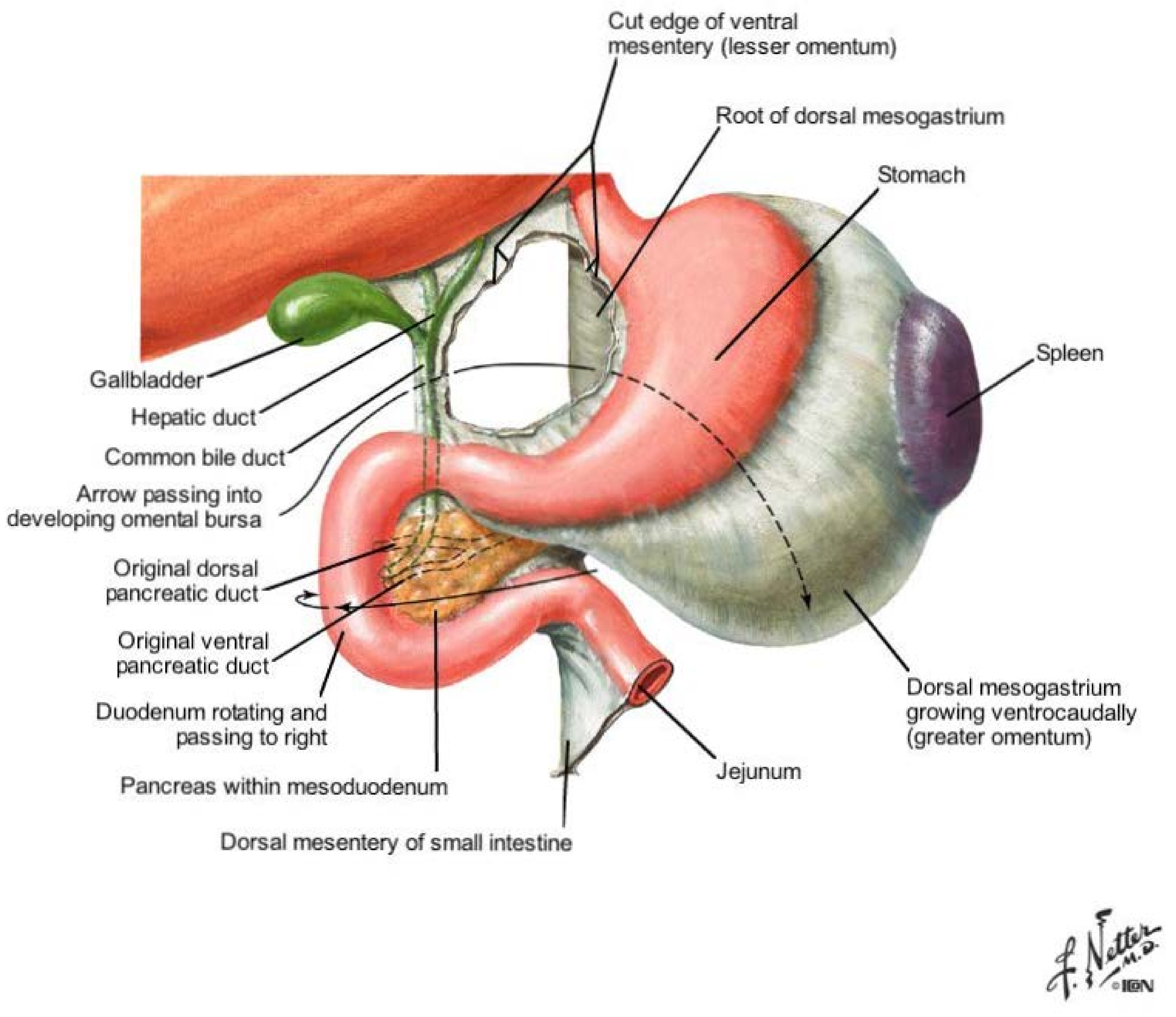
Foregut and Midgut Rotations
8 weeks



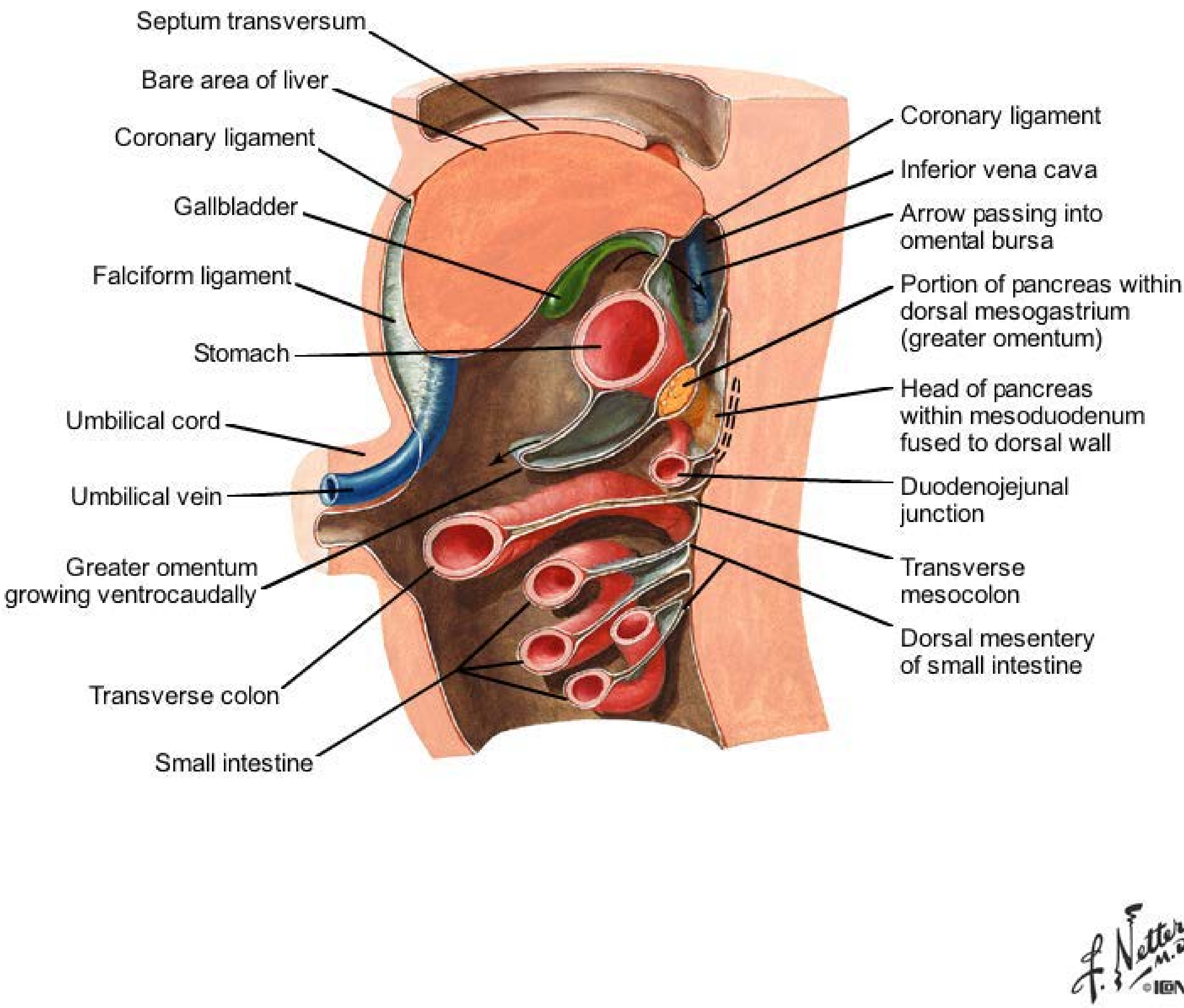
Merkel's Diverticulum



Lesser Peritoneal Sac
2 months

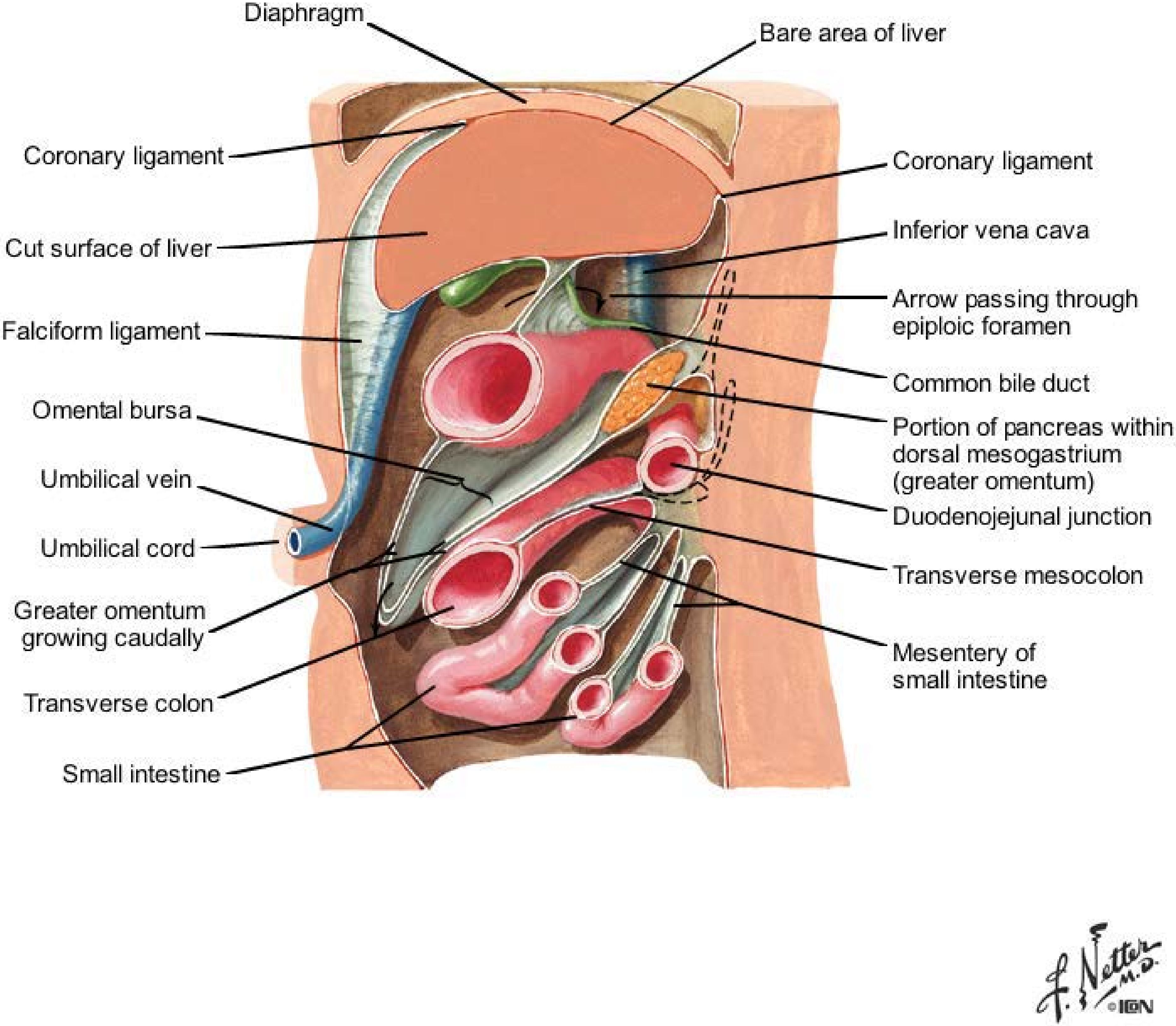


Lesser Peritoneal Sac
2 to 3 months

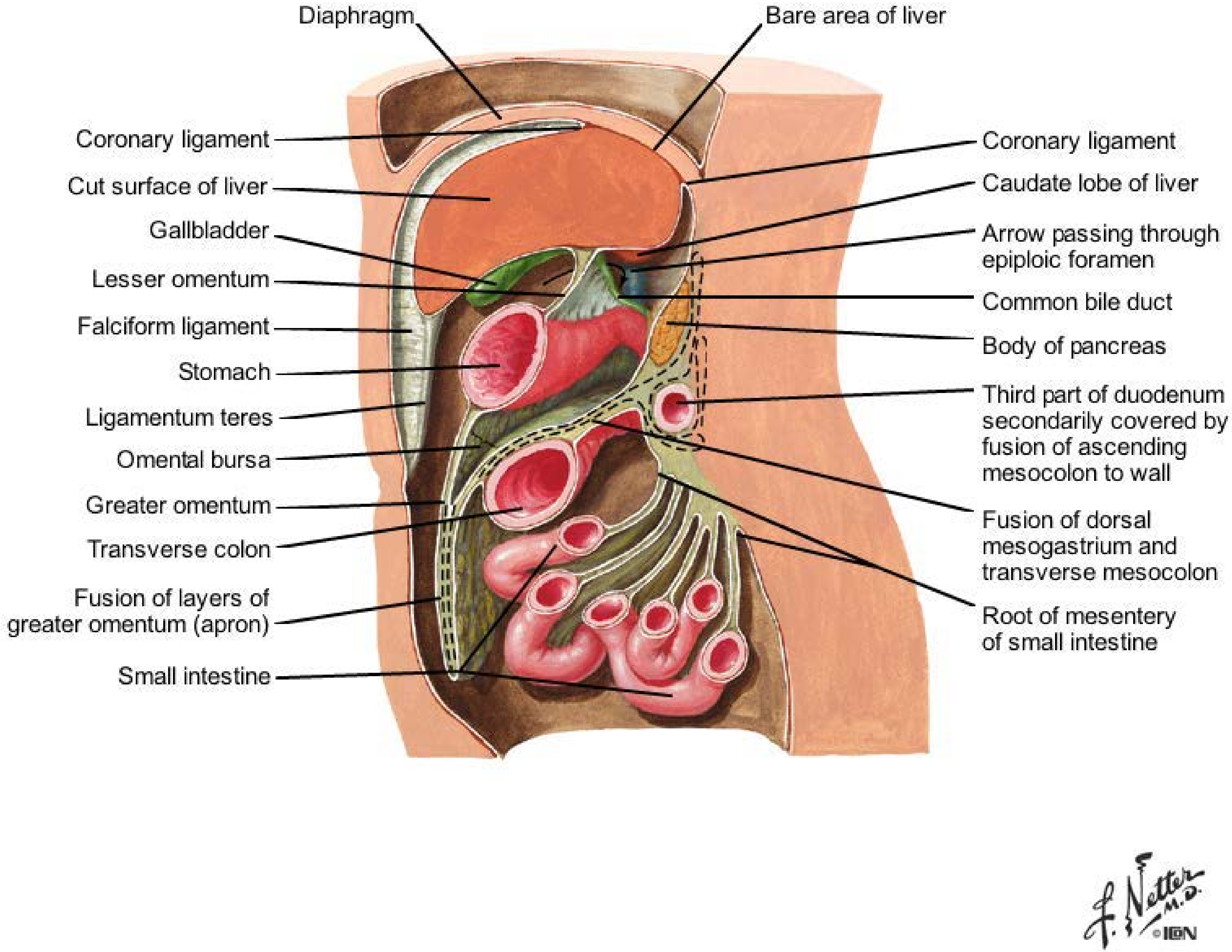


Introduction to the Retroperitoneal Concept

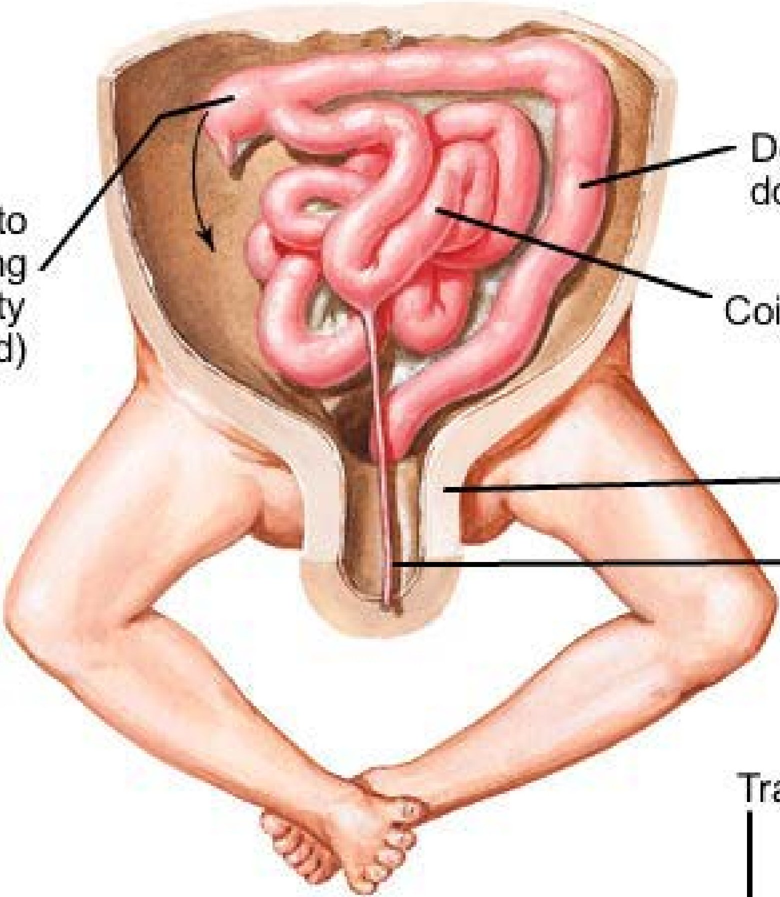
3 to 4 months

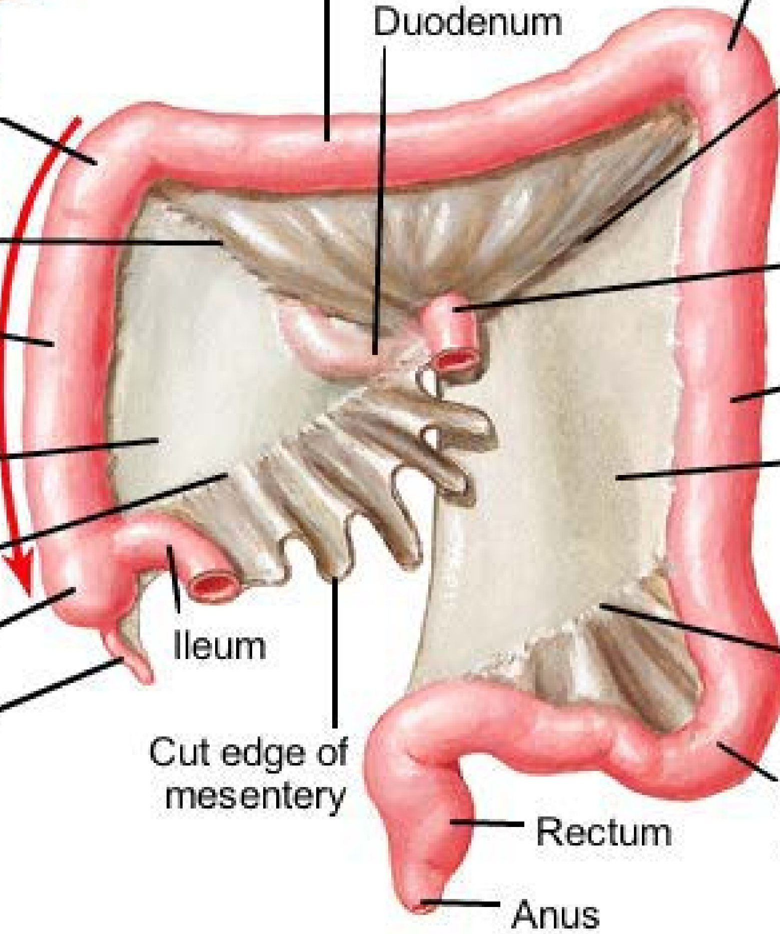


Introduction to the Retroperitoneal Concept
Adult relationships

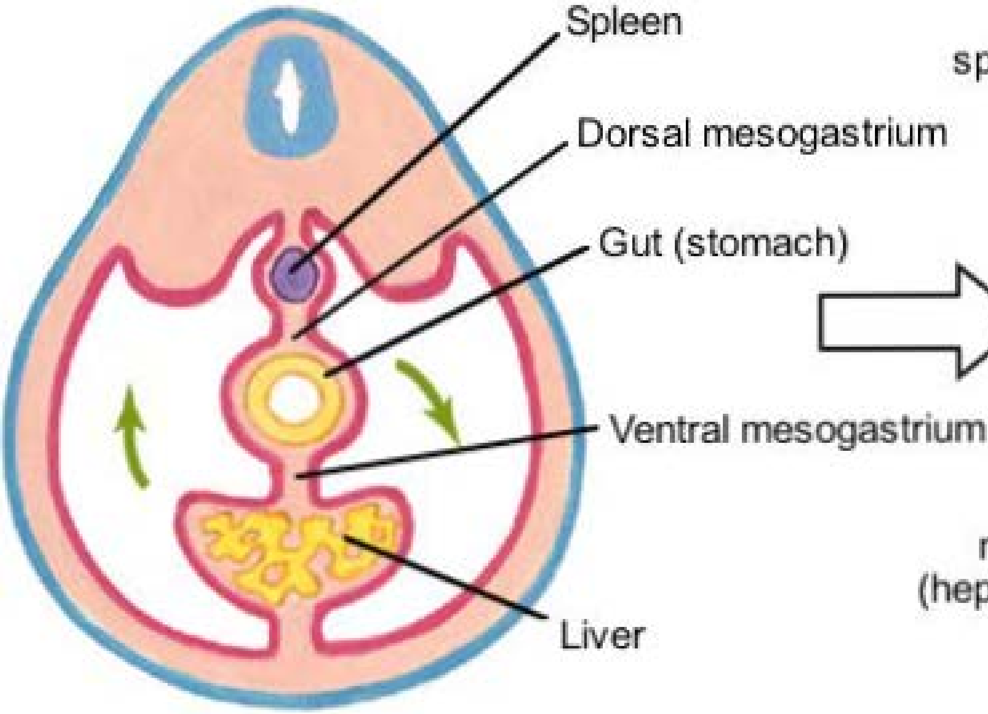


Midgut Loop

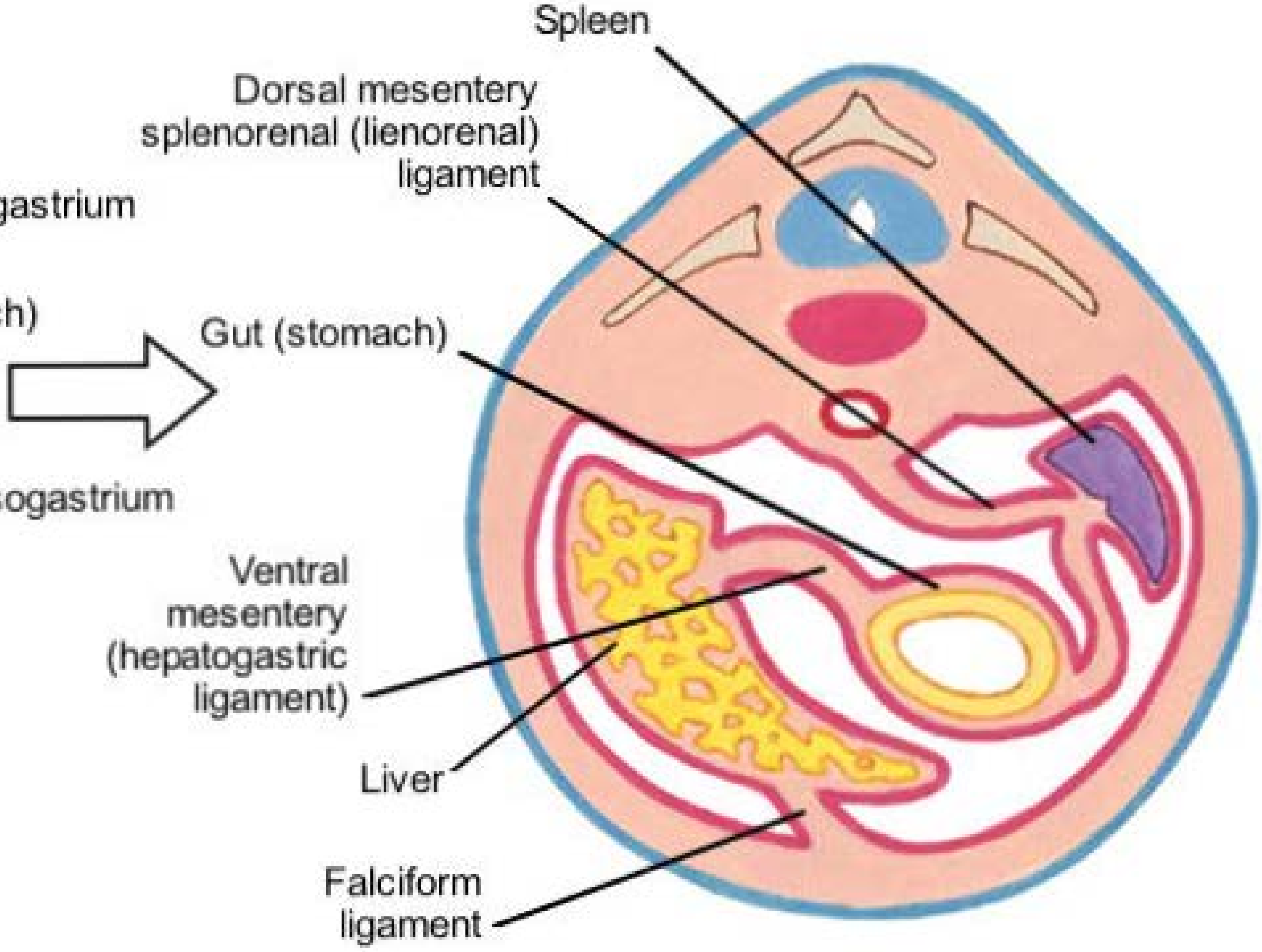

10 weeks
Cecum (continuing to rotate after returning last to abdominal cavity from umbilical cord)
Descending colon against dorsal abdominal wall
Coiled small intestine
Umbilical cord
Disappearing yolk stalk


4 to 5 months
Transverse colon
Left colic flexure
Duodenum
Root of transverse mesocolon (left half)
Right colic flexure
Root of transverse mesocolon (right half)
Duodenojejunal flexure
Ascending colon
Descending colon
Triangular fusion of ascending mesocolon to dorsal wall
Quadrangular fusion of descending mesocolon to dorsal wall
Root of mesentery of small intestine
Cecum in final position of rotation
Ileum
Root of sigmoid mesocolon
Vermiform appendix
Cut edge of mesentery
Sigmoid colon
Rectum
Anus
F. Netter M.D.
©ICON

Abdominal Ligaments

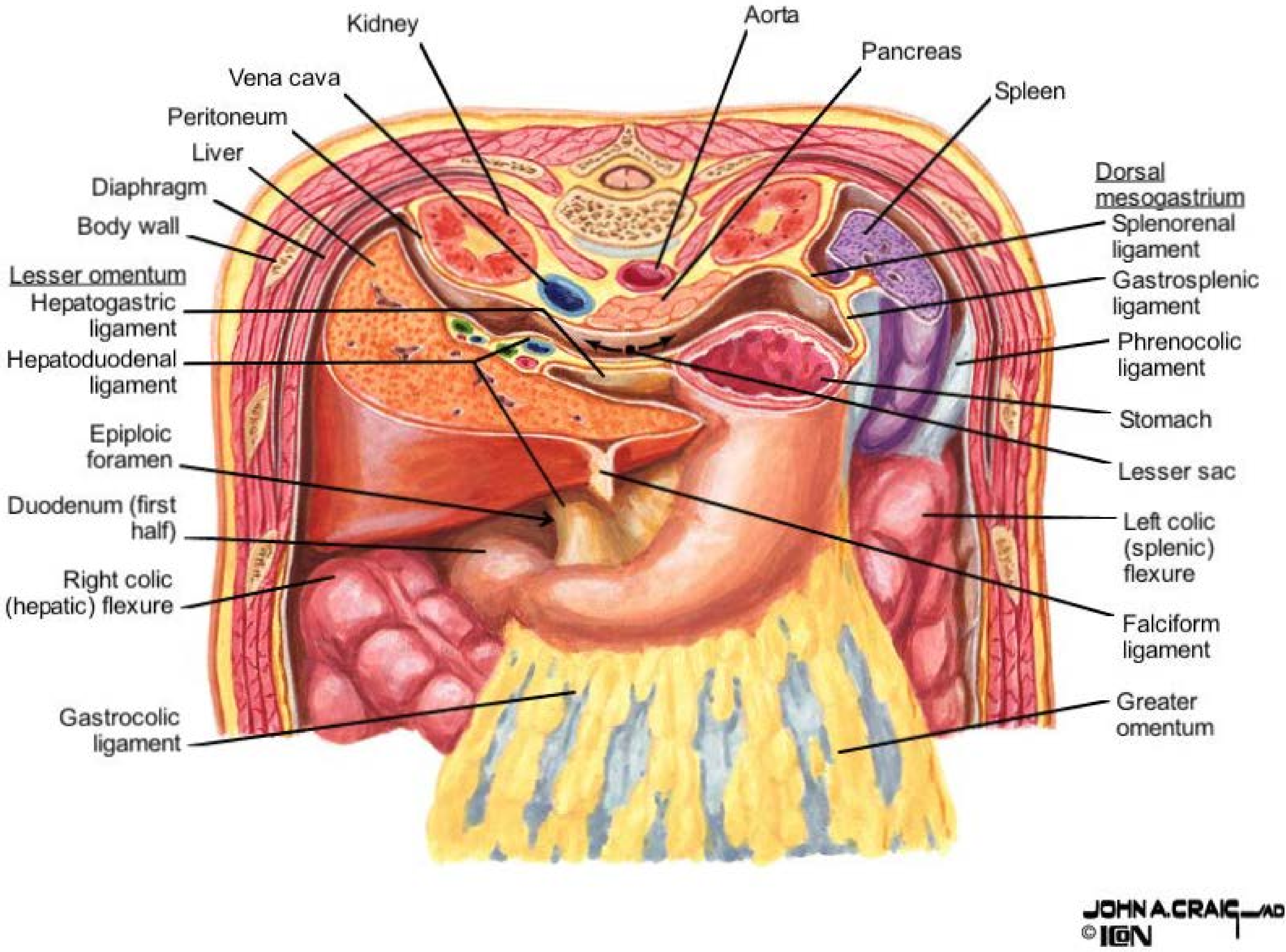


Primitive configuration of abdomen

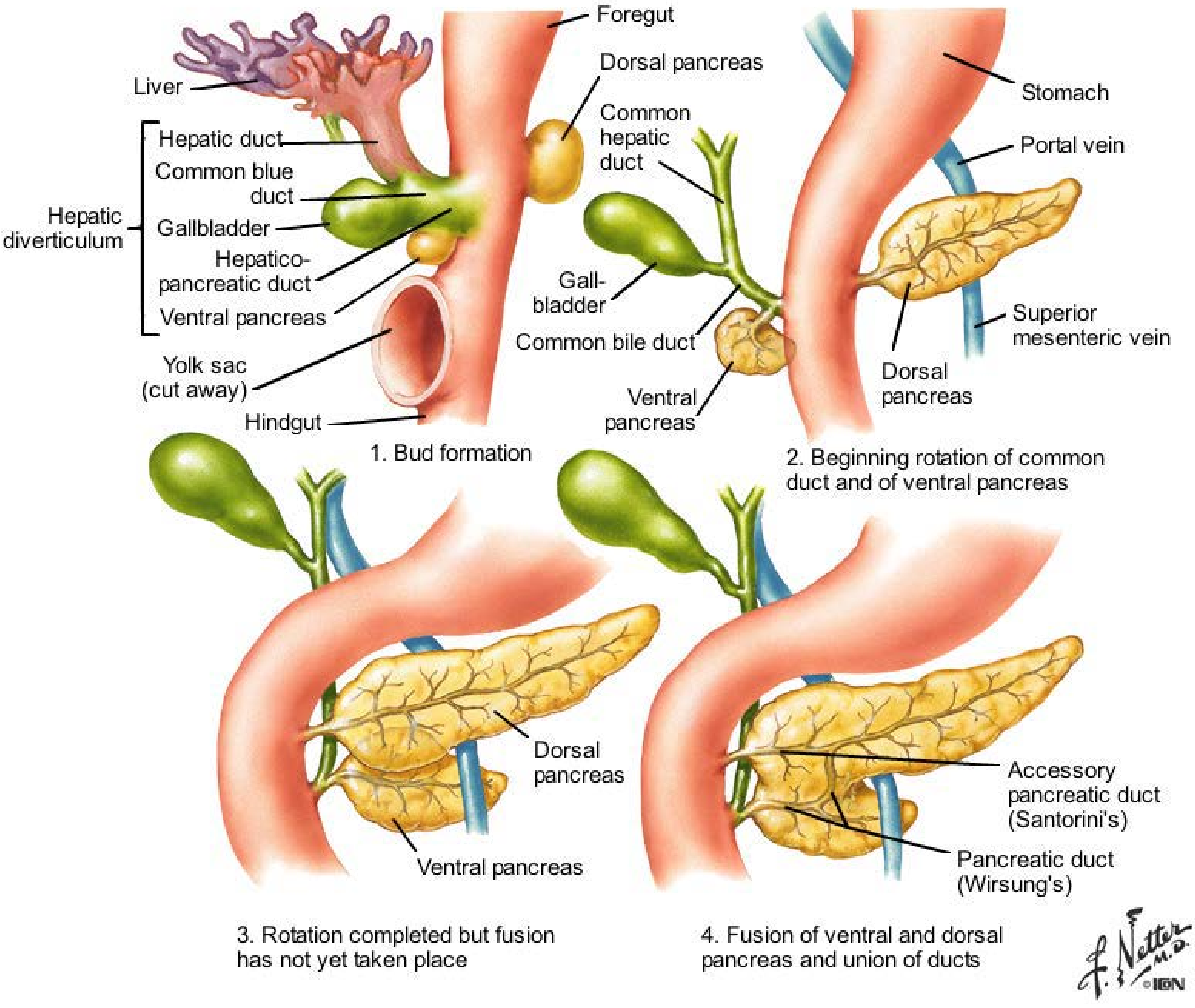


Configuration of abdominal organs and mesenteries after gut rotation

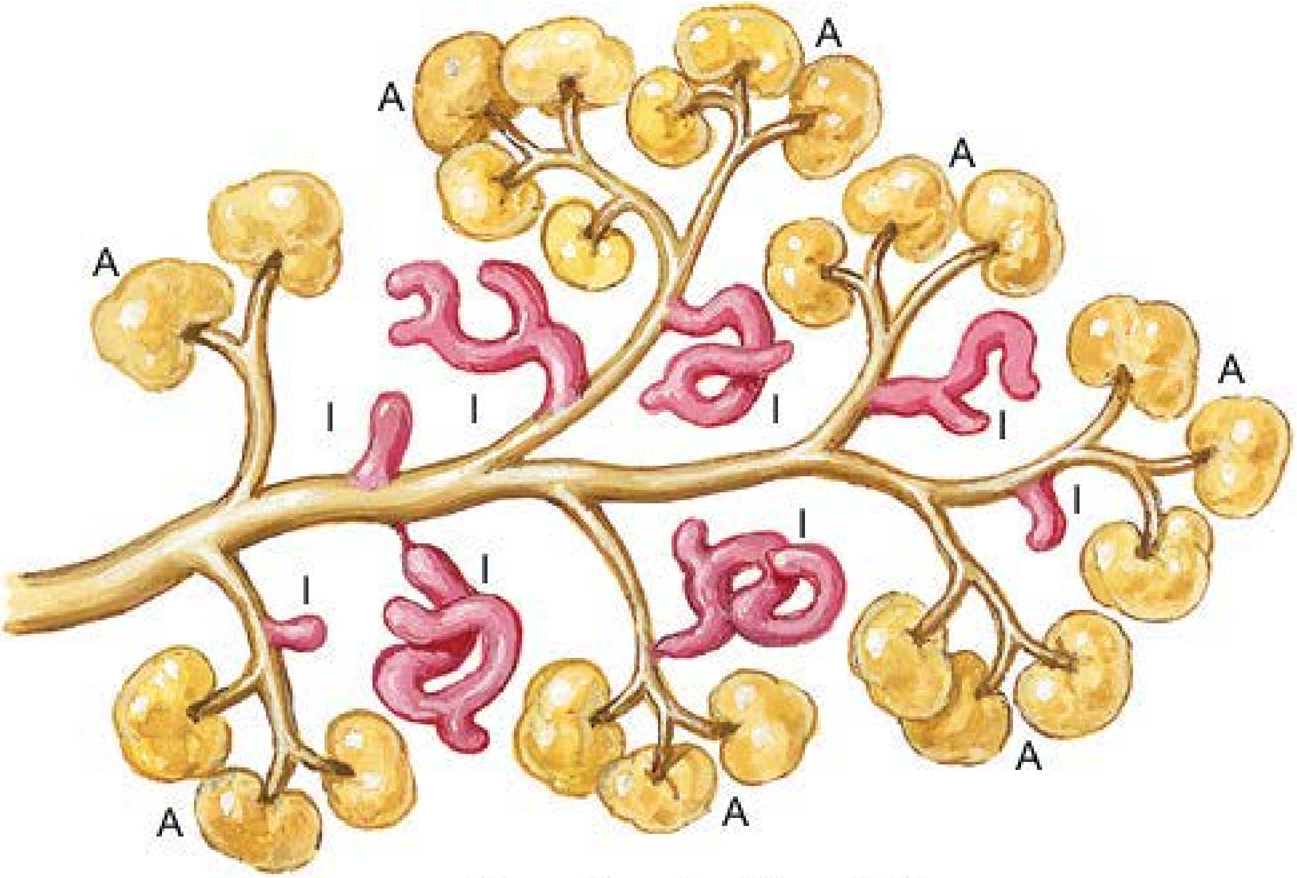
Abdominal Ligaments



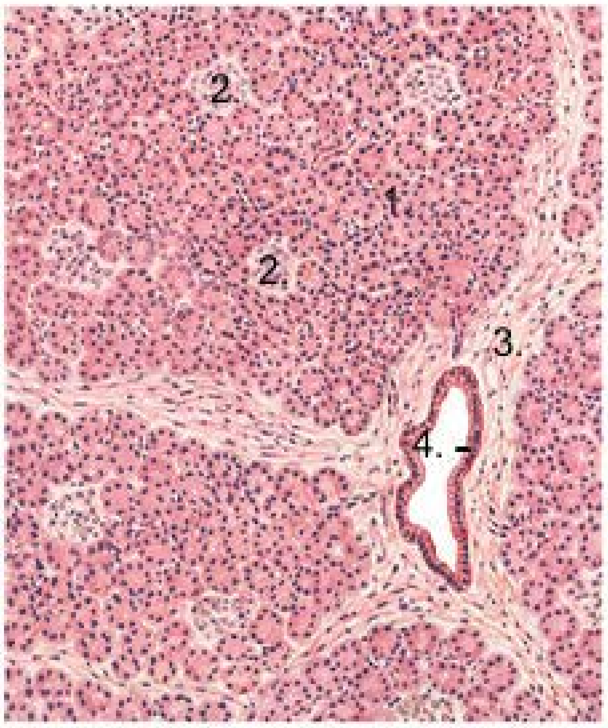
Abdominal Foregut Organ Development



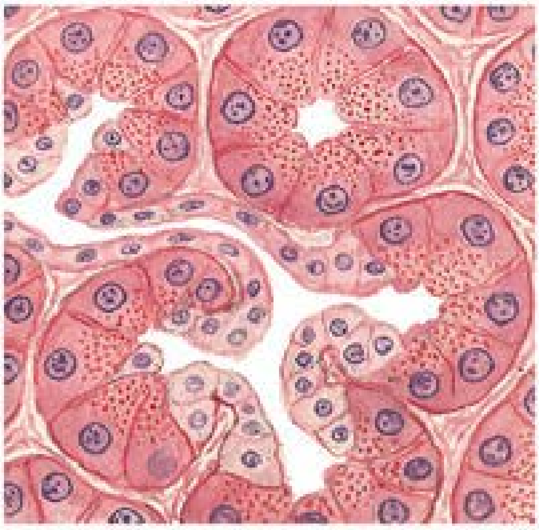
Development of Pancreatic Acini and Islets



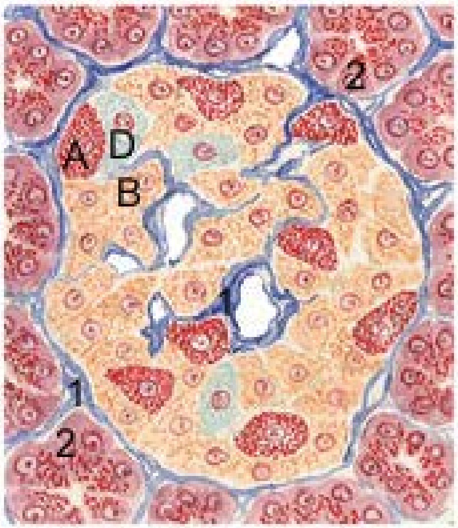
Formation of acini and islets from ducts. **A**-acini; **I**-islets in various stages of development



Low-power section of pancreas **1**. Acini, **2**. islet, **3**. interlobular septum, **4**. interlobular duct

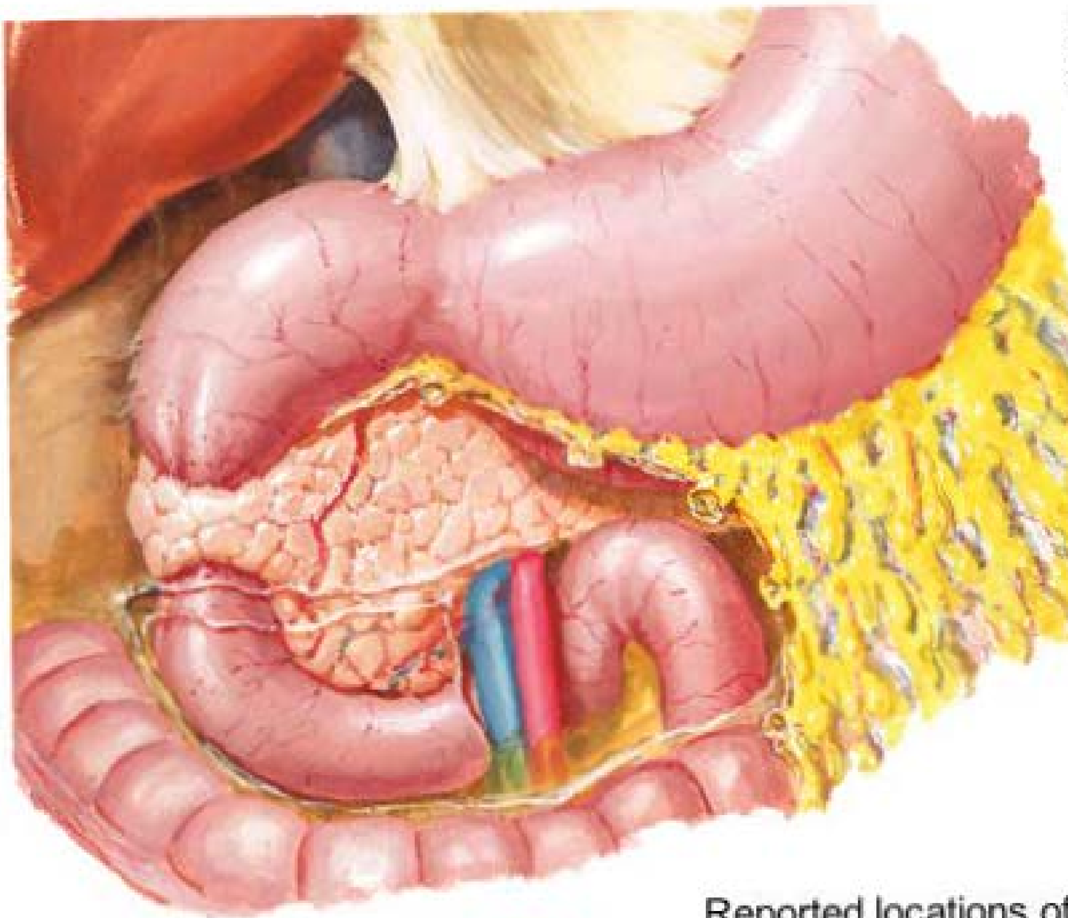


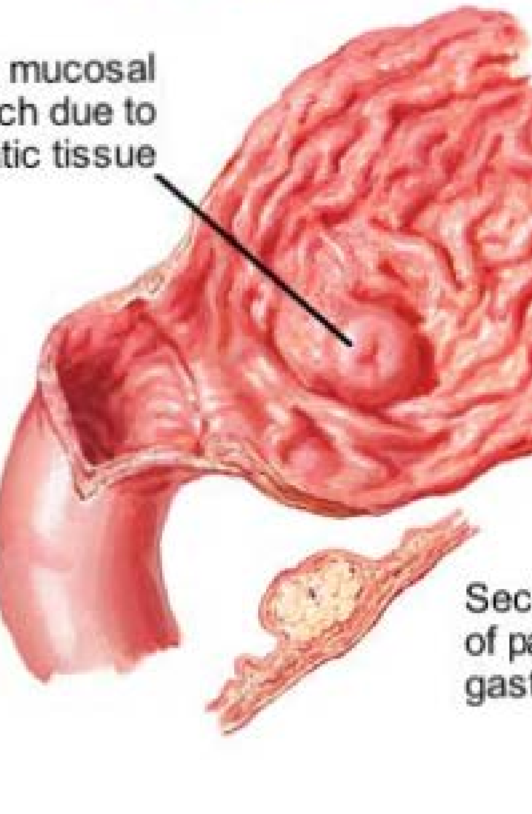
High magnification: relationship of intercalated duct and centroacinar cells to acini



Pancreatic islet
A (=α-), **B** (=ß-) and **D**-cells.
1. reticulum, 2. acini

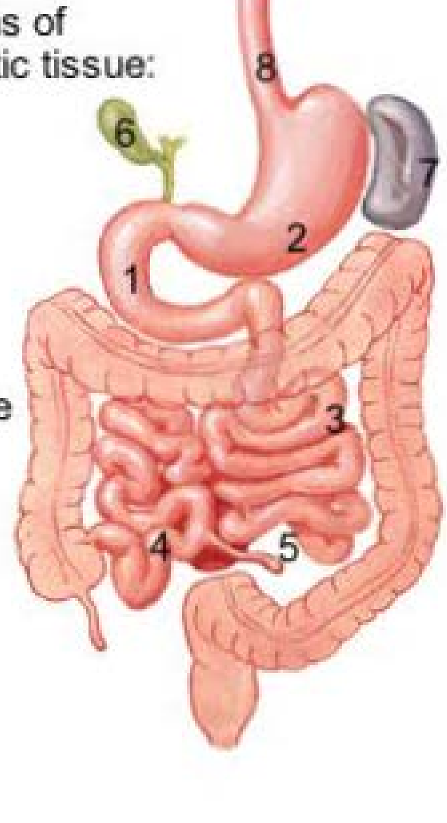
Congenital Pancreatic Anomalies



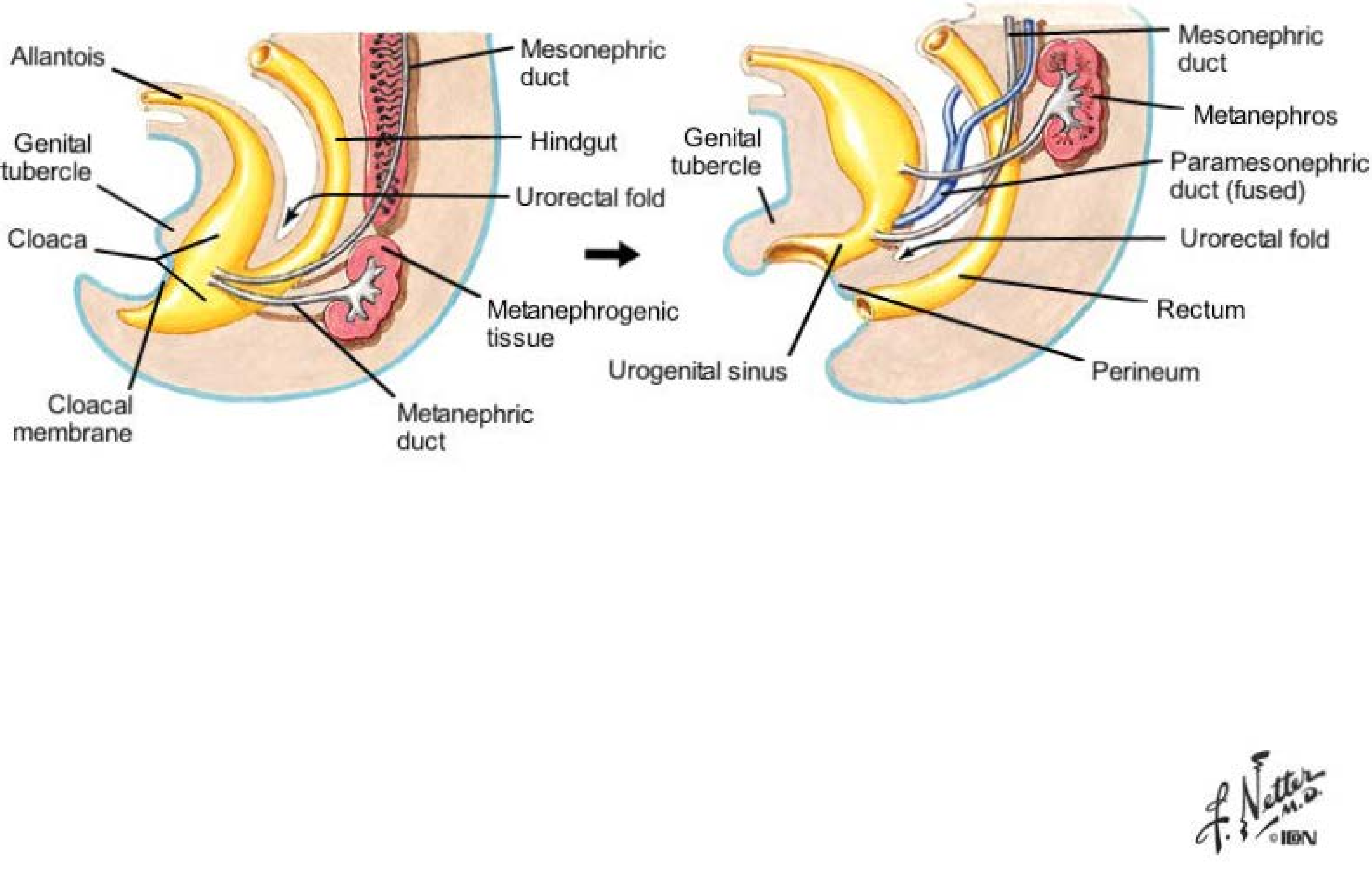


Reported locations of aberrant pancreatic tissue:

1. Duodenum
2. Stomach
3. Jejunum
4. Ileum
5. Meckel's diverticulum
6. Gallbladder
7. Splenic capsule
8. Esophagus

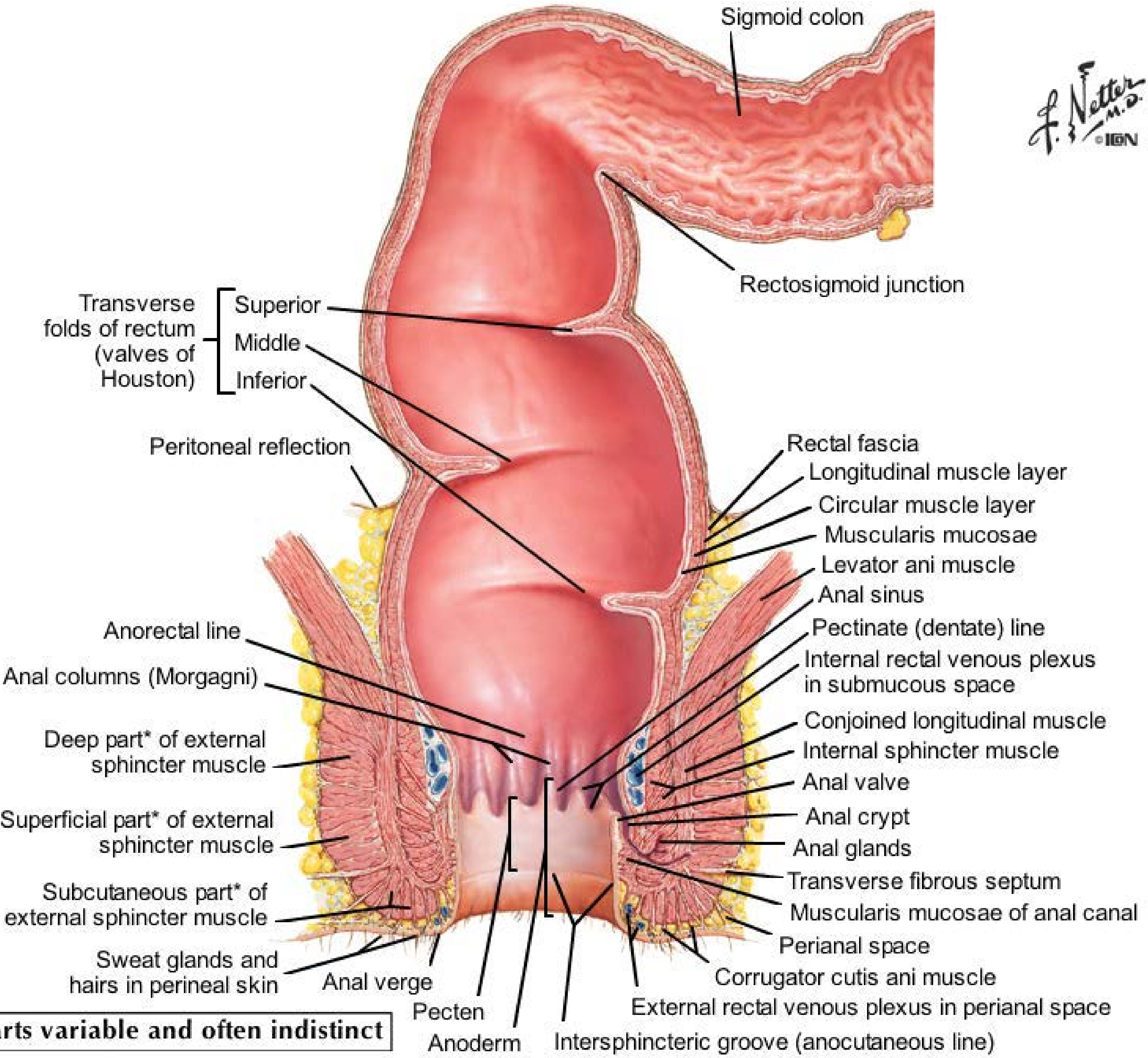


Development of the Hindgut



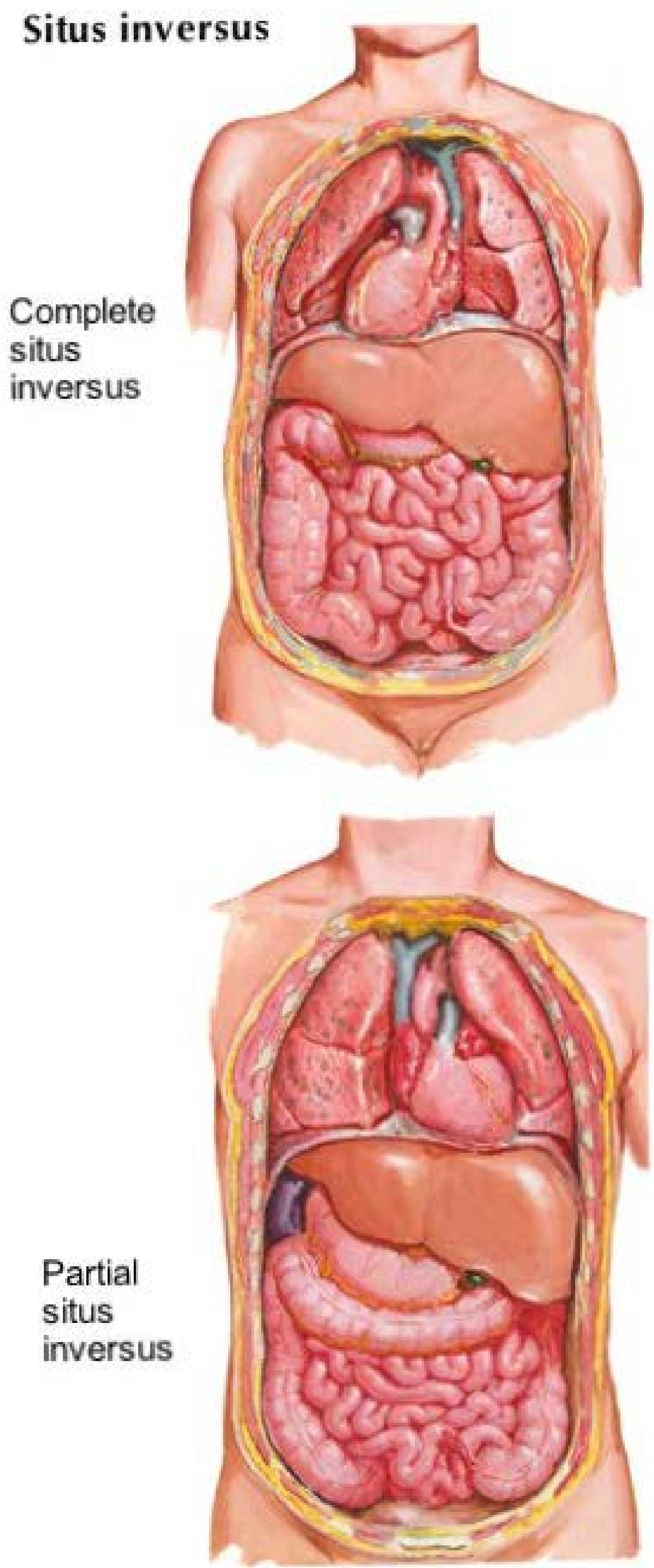
Development of the Hindgut

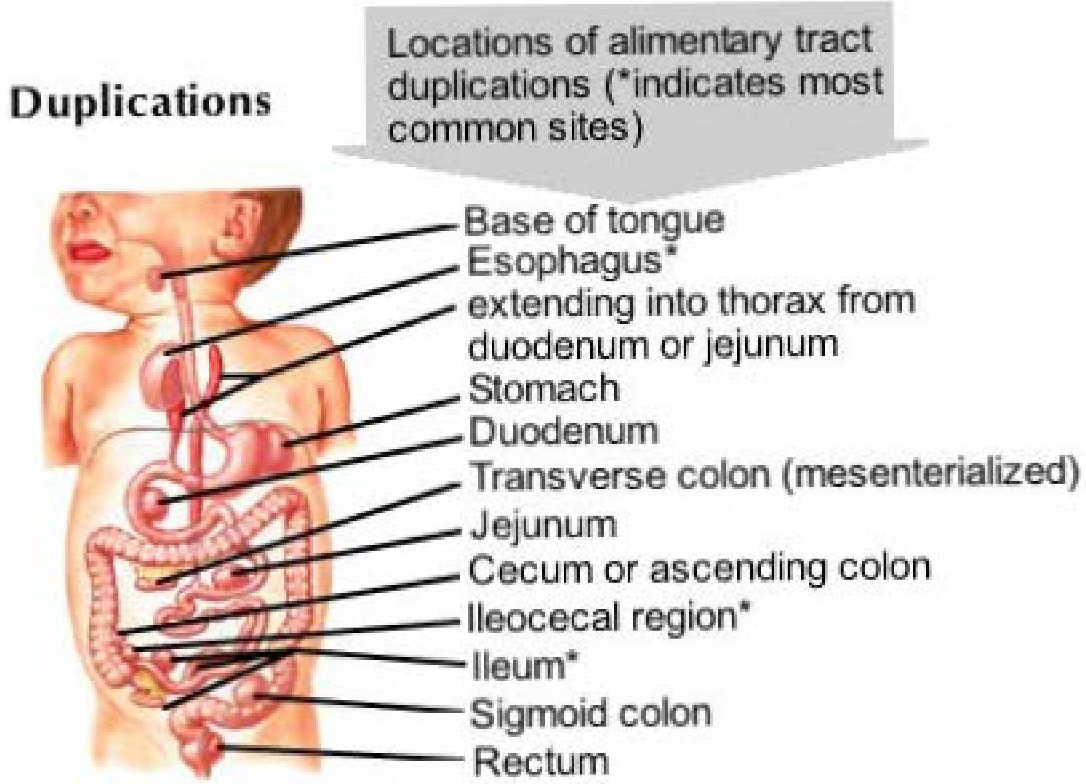
Adult rectum and anal canal

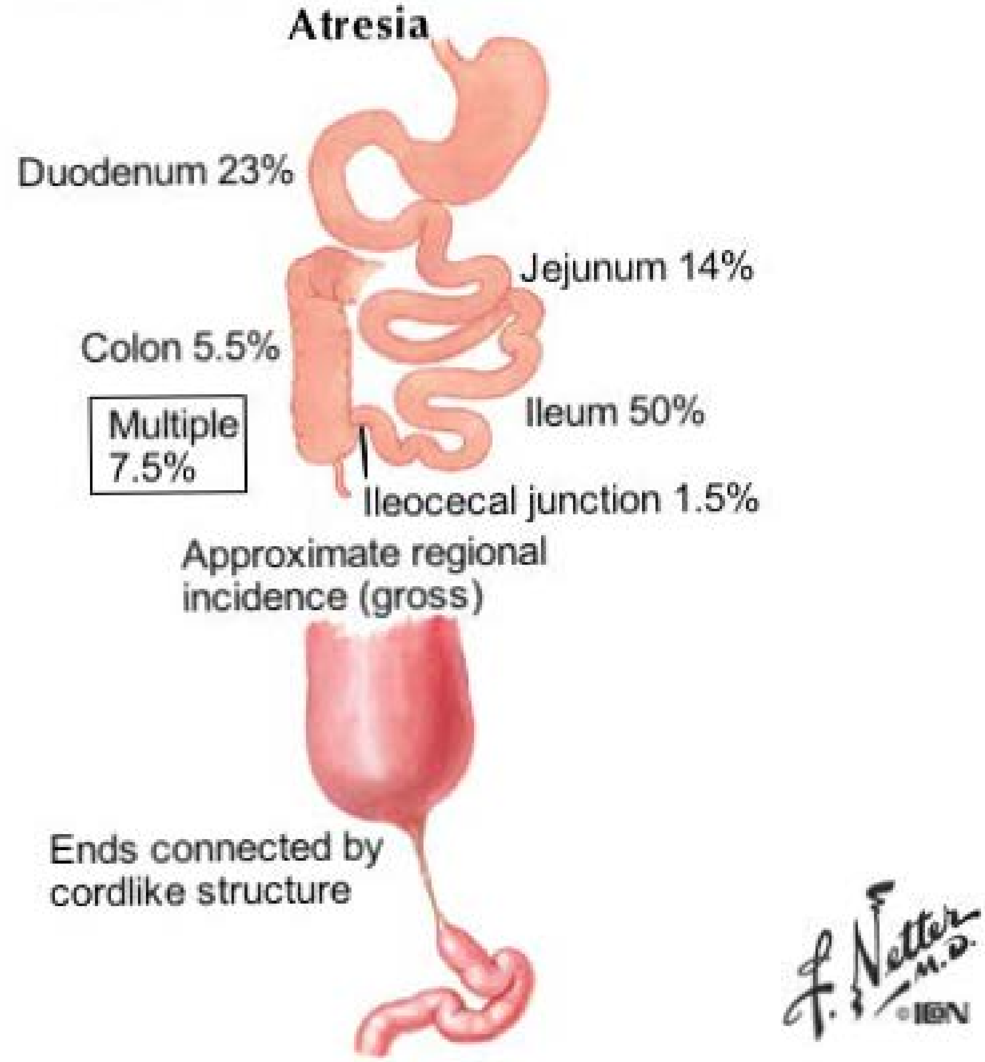


*Parts variable and often indistinct

Congenital Anomalies







Congenital Anomalies
Megacolon (Hirschsprung's Disease)

Tremendous distention and hypertrophy of sigmoid and descending colon; moderate involvement of transverse colon; distal constricted segment

Typical abdominal distention

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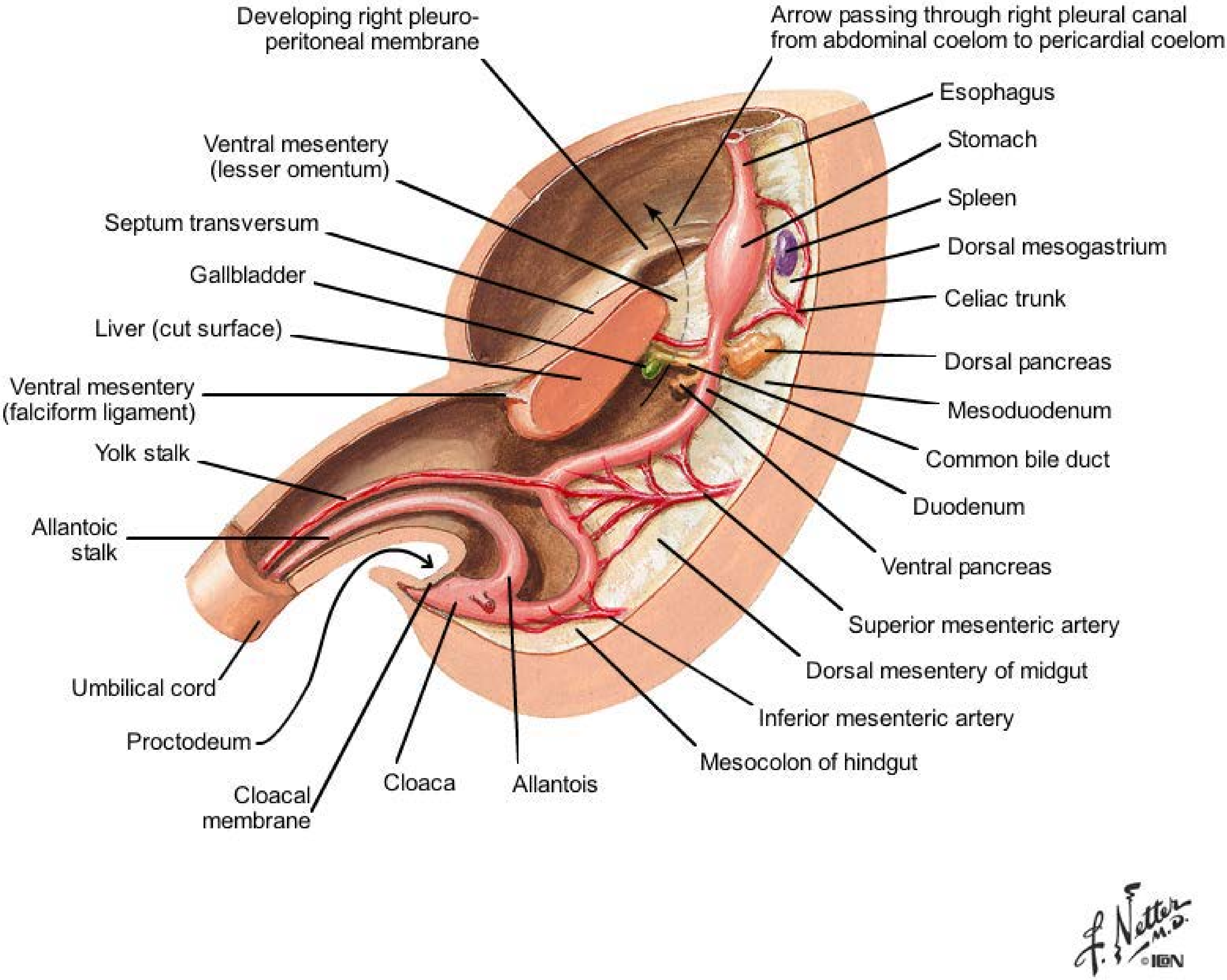
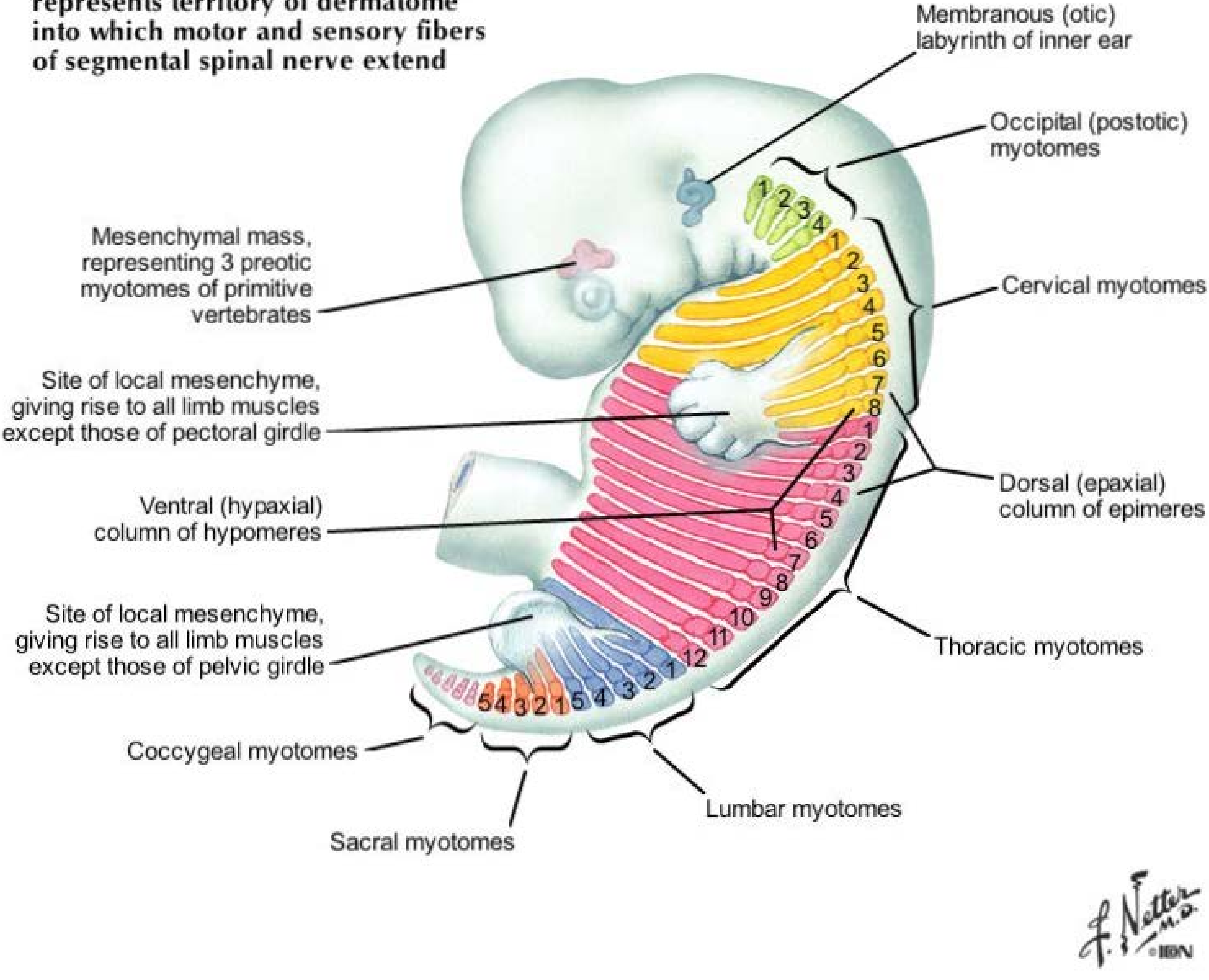
Summary of Gut Organization
5 weeks



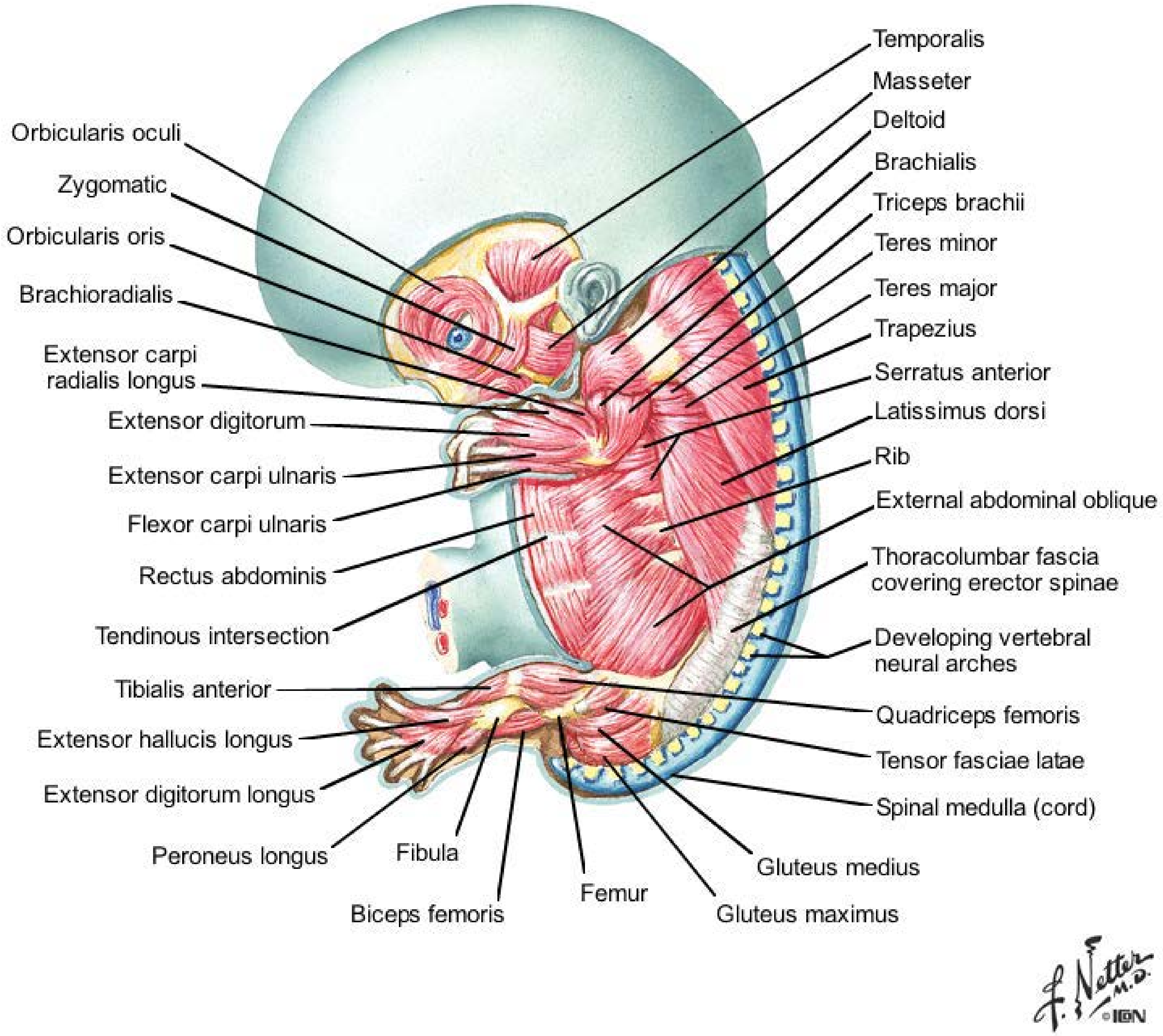
Development of the Abdominal Wall
Segmental distribution of myotomes in fetus of 6 weeks

Region of each trunk myotome also represents territory of dermatome into which motor and sensory fibers of segmental spinal nerve extend

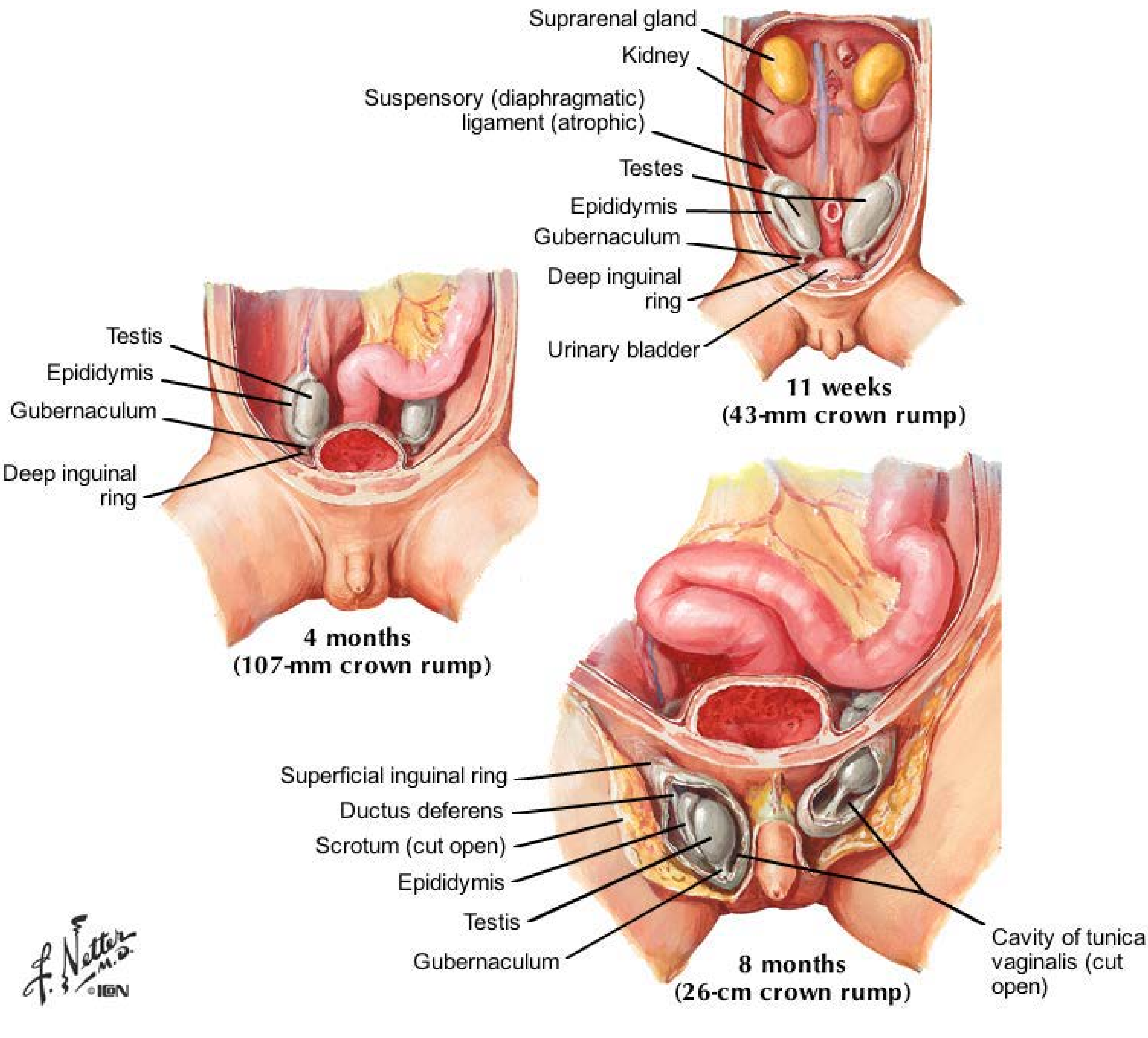


Development of the Abdominal Wall

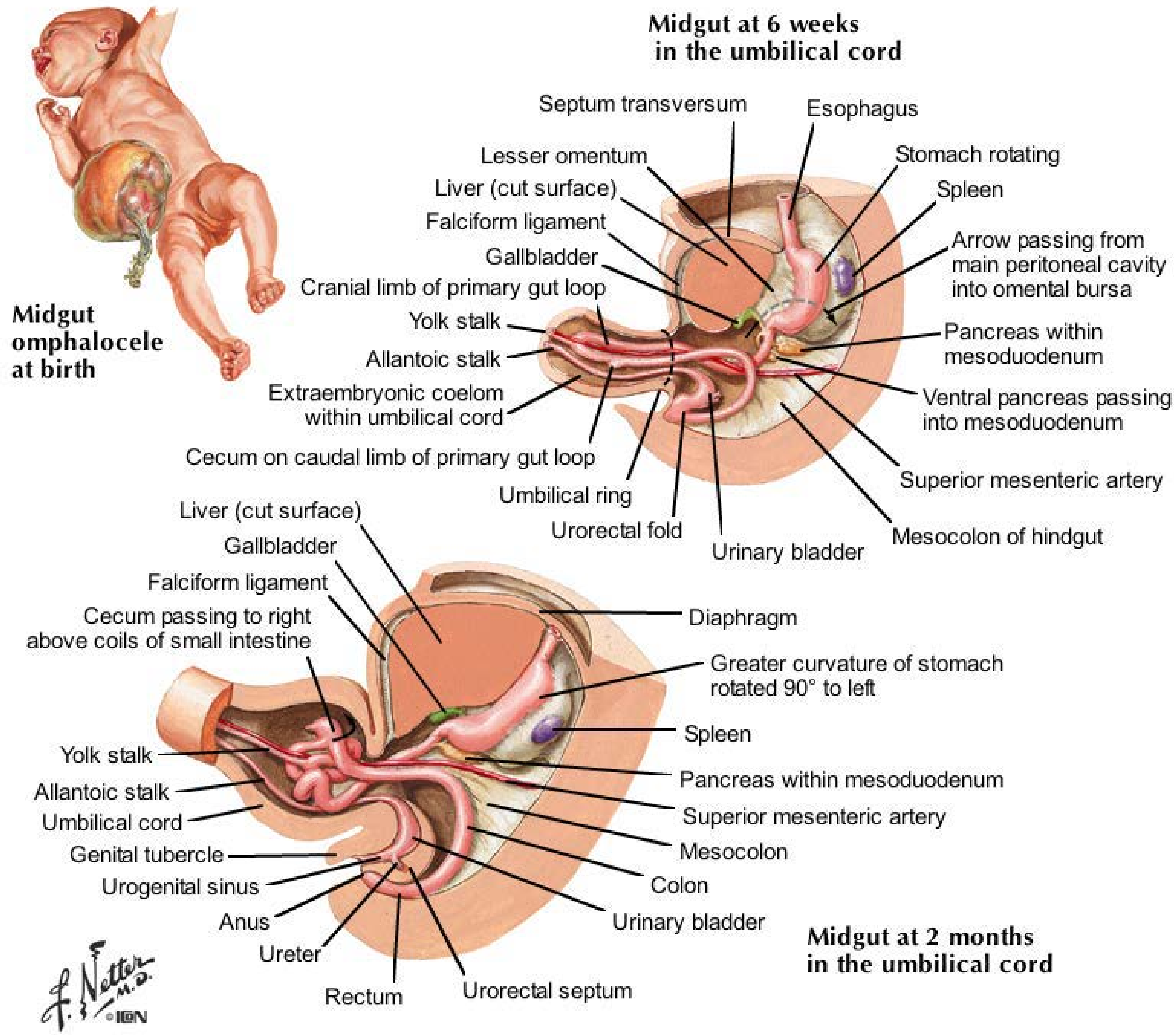
Developing skeletal muscles at 8 weeks (superficial dissection)



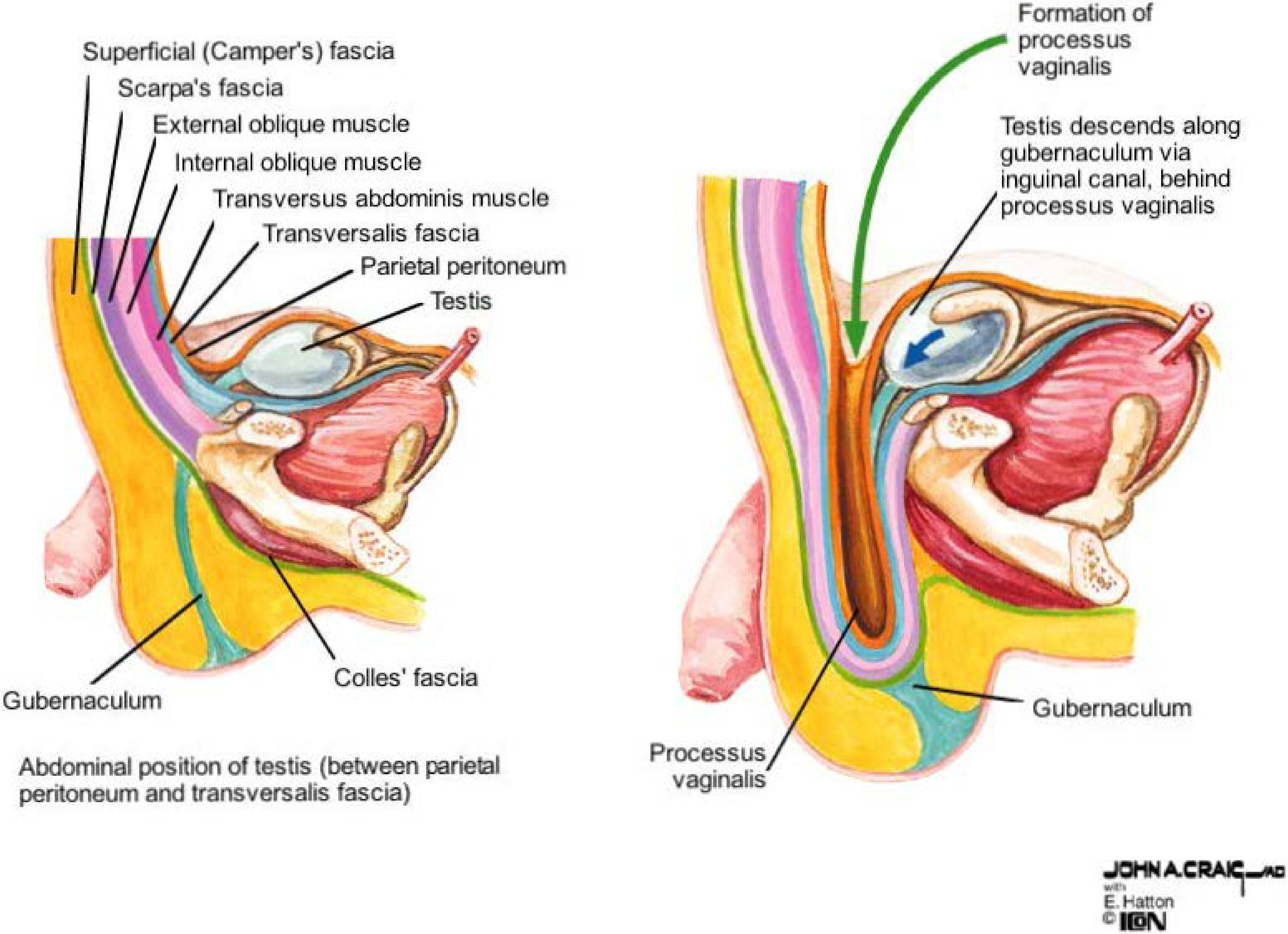
The Inguinal Region



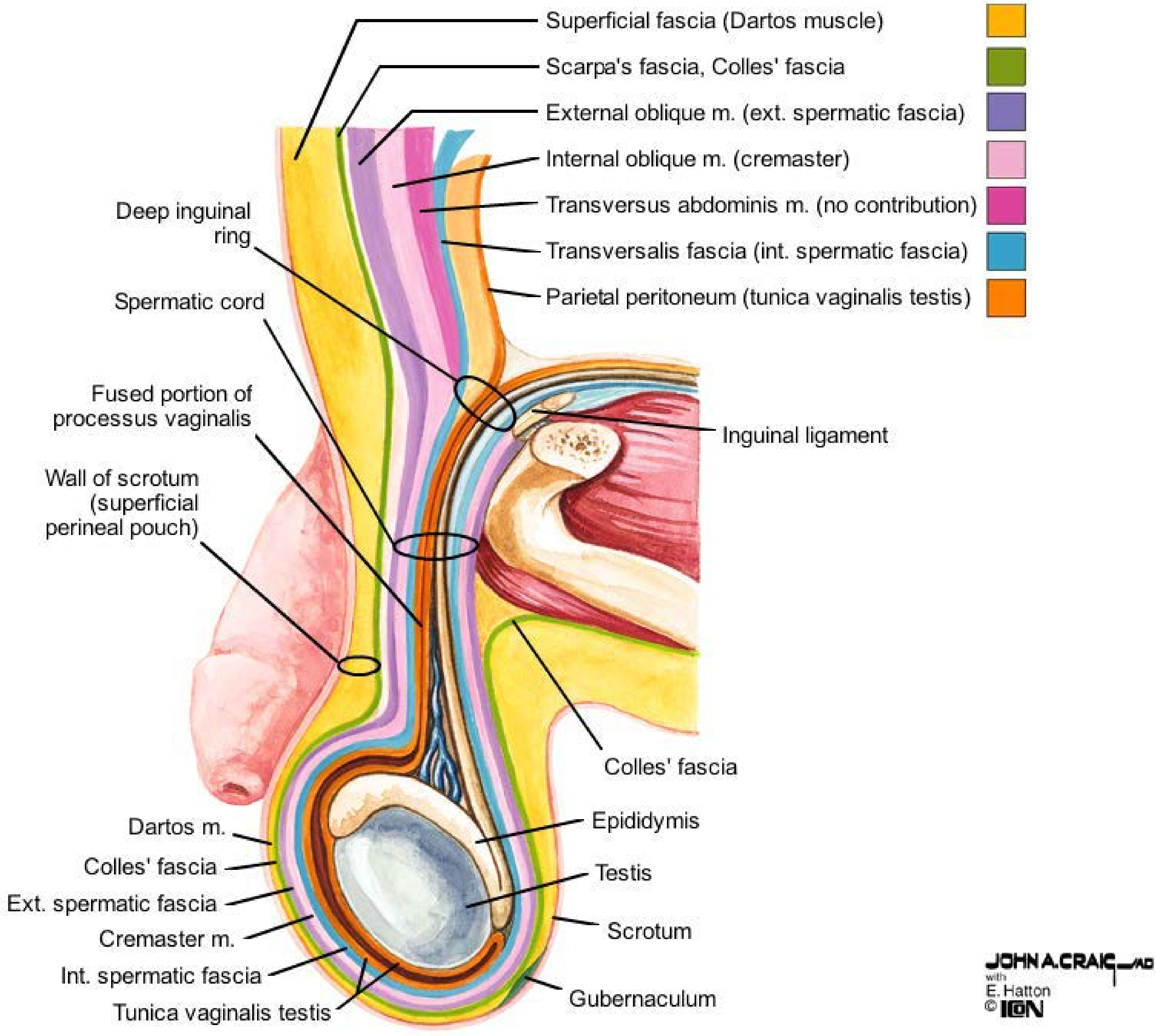
Umblical Hernia



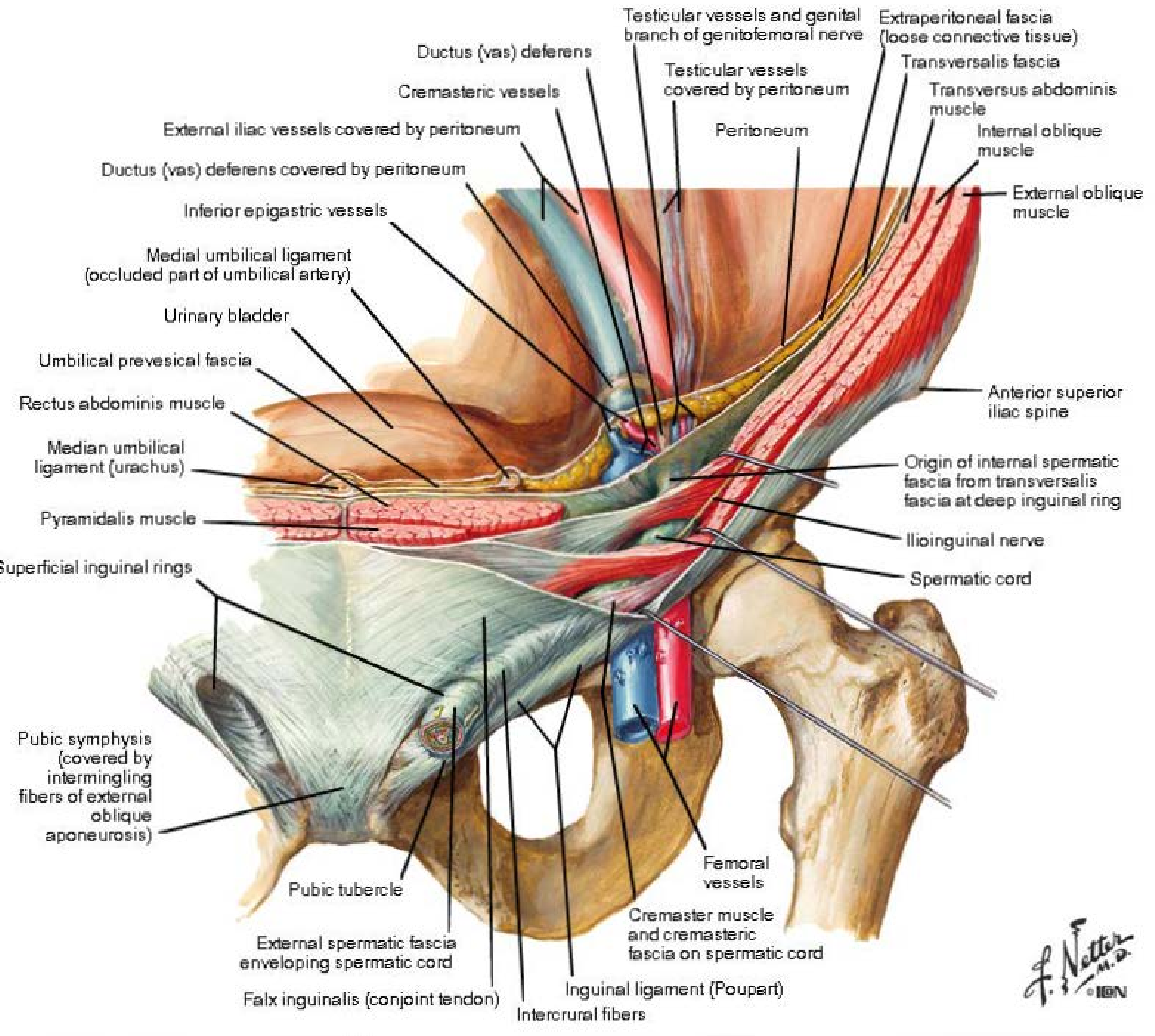
Anterior Testis Decent
Testicular descent



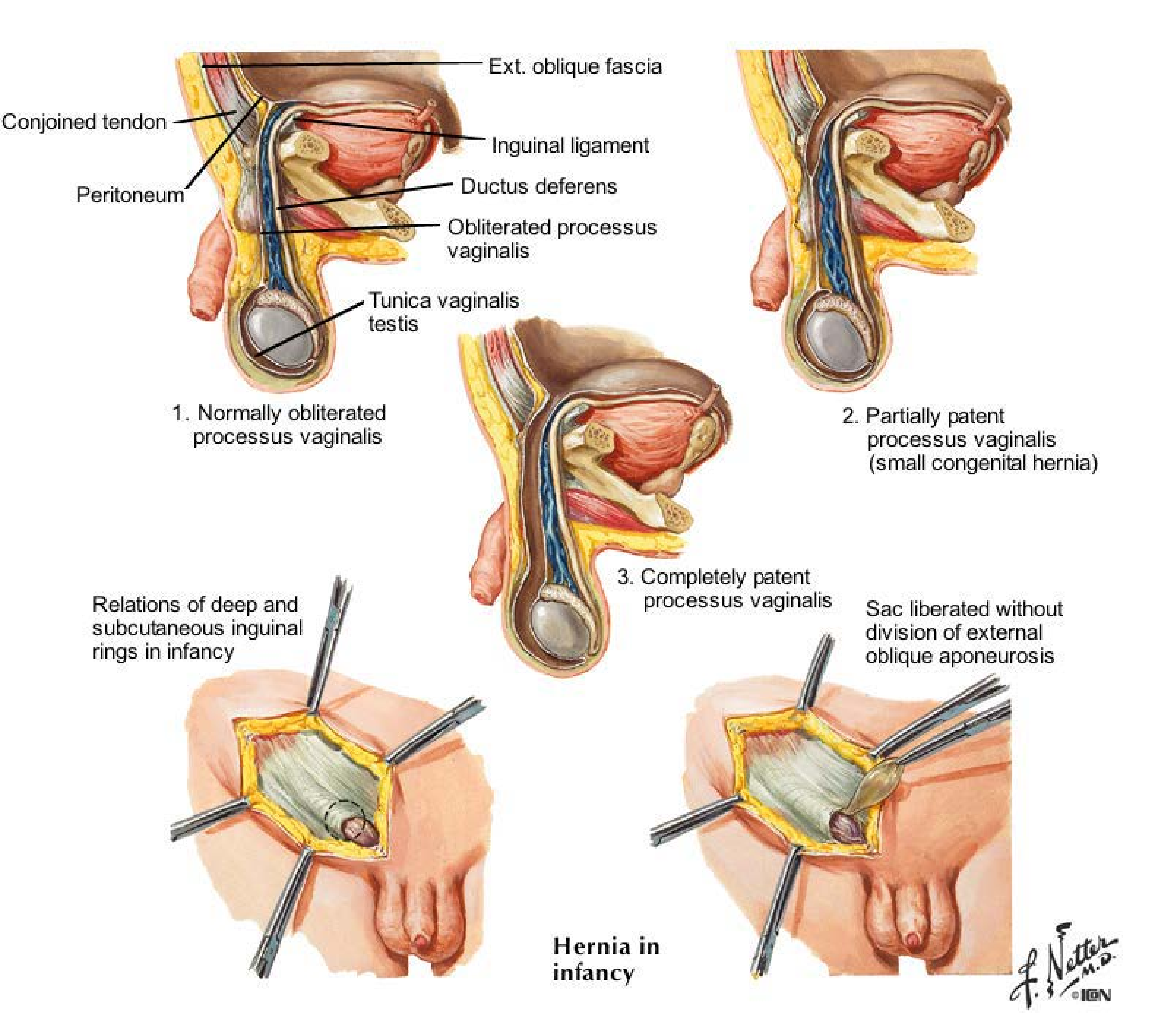
Anterior Testis Descent
Adult configuration



The Adult Inguinal Region



Anomalies of the Processus Vaginalis

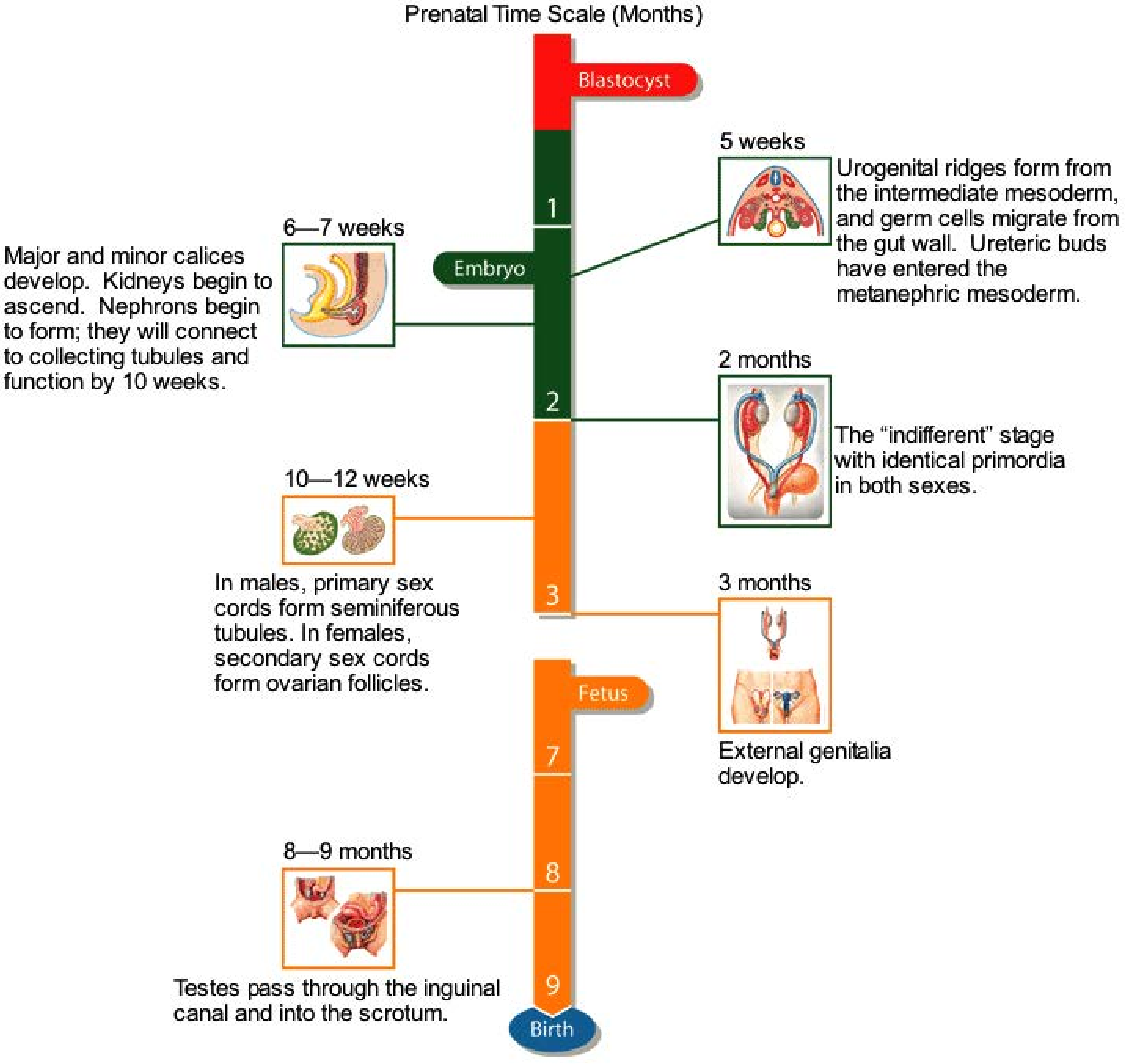


Organization of the Abdominal GI Tract

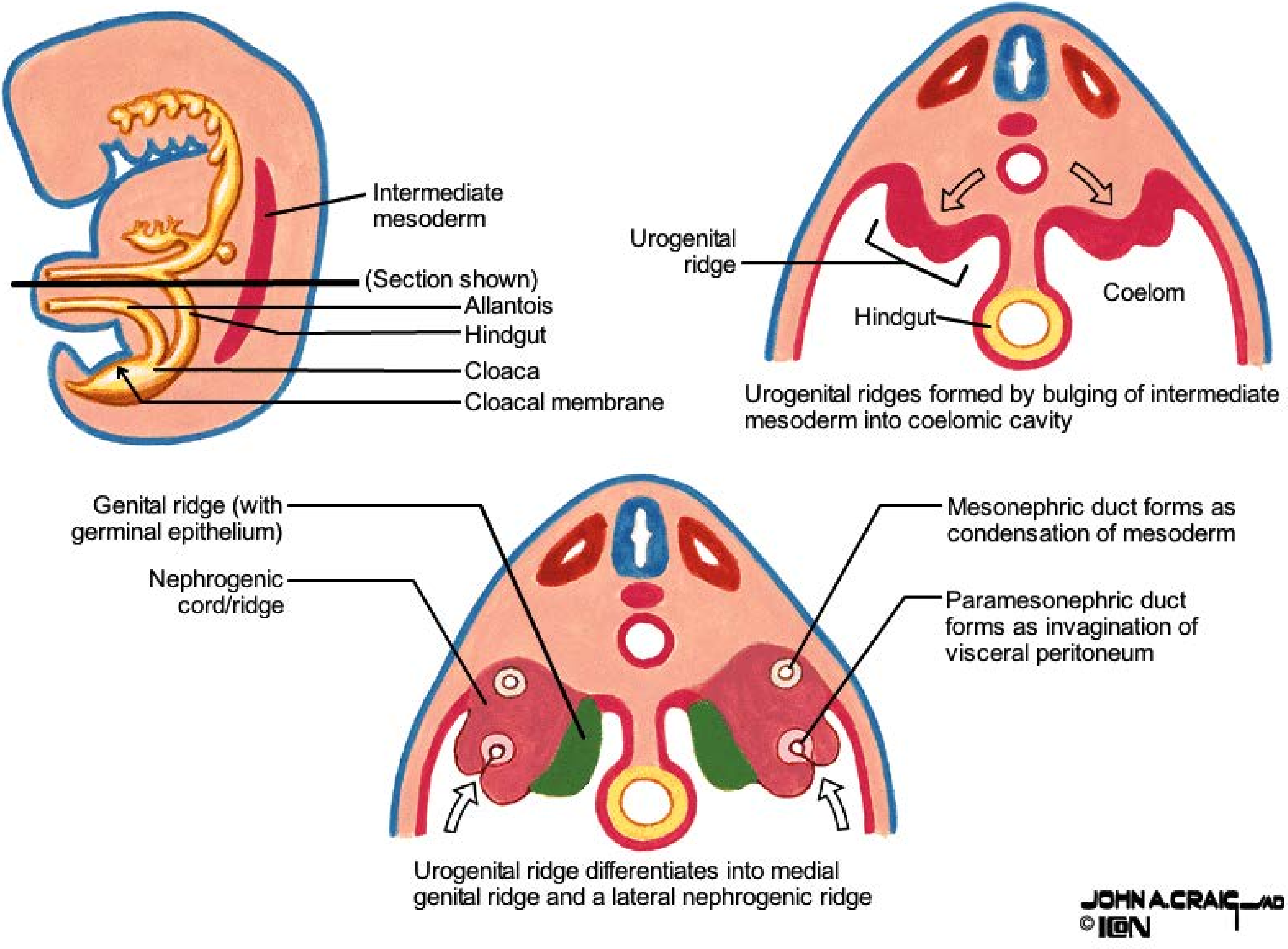
ORGANIZATION OF THE ABDOMINAL GI TRACT

	Foregut	Midgut	Hindgut
Organs	Stomach Liver Gallbladder Pancreas Spleen 1st half of duodenum	2nd half of duodenum Jejunum and ileum Cecum Ascending colon $^2/_3$ of transverse colon	Left $^1/_3$ of transverse colon Descending colon Sigmoid colon Rectum
Arteries	Celiac trunk: Splenic artery Left gastric Common hepatic	Superior mesenteric: Ileocolic Right colic Middle colic	Inferior mesenteric: Left colic Sigmoid branches Superior rectal
Ventral mesentery	Lesser omentum Falciform ligament Coronary/triangular ligaments	None	None
Dorsal mesentery	Gastrosplenic ligament Splenorenal ligament Gastrocolic ligament Greater omentum	Mesointestine Mesoappendix Transverse mesocolon	Sigmoid mesocolon
Motor nerve supply	Vagus	Vagus	Pelvic splanchnic nerves

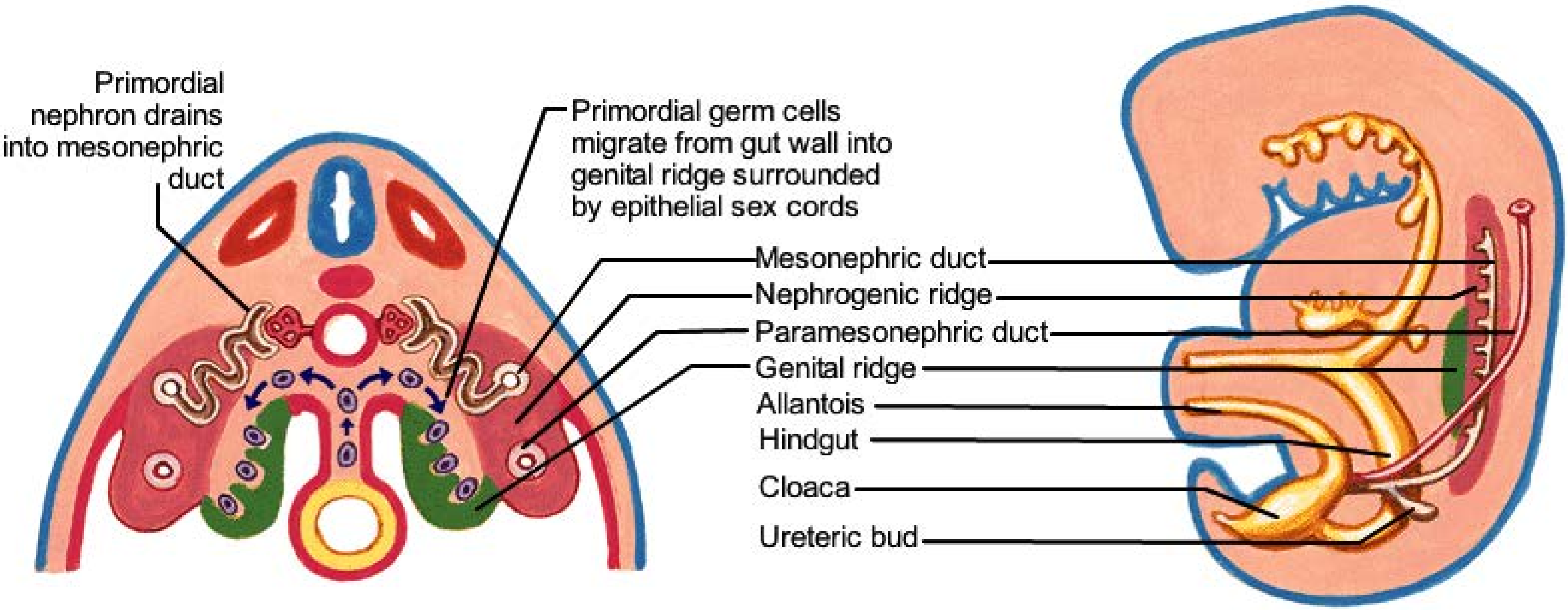
THE UROGENITAL SYSTEM
TIMELINE



Early Primordia

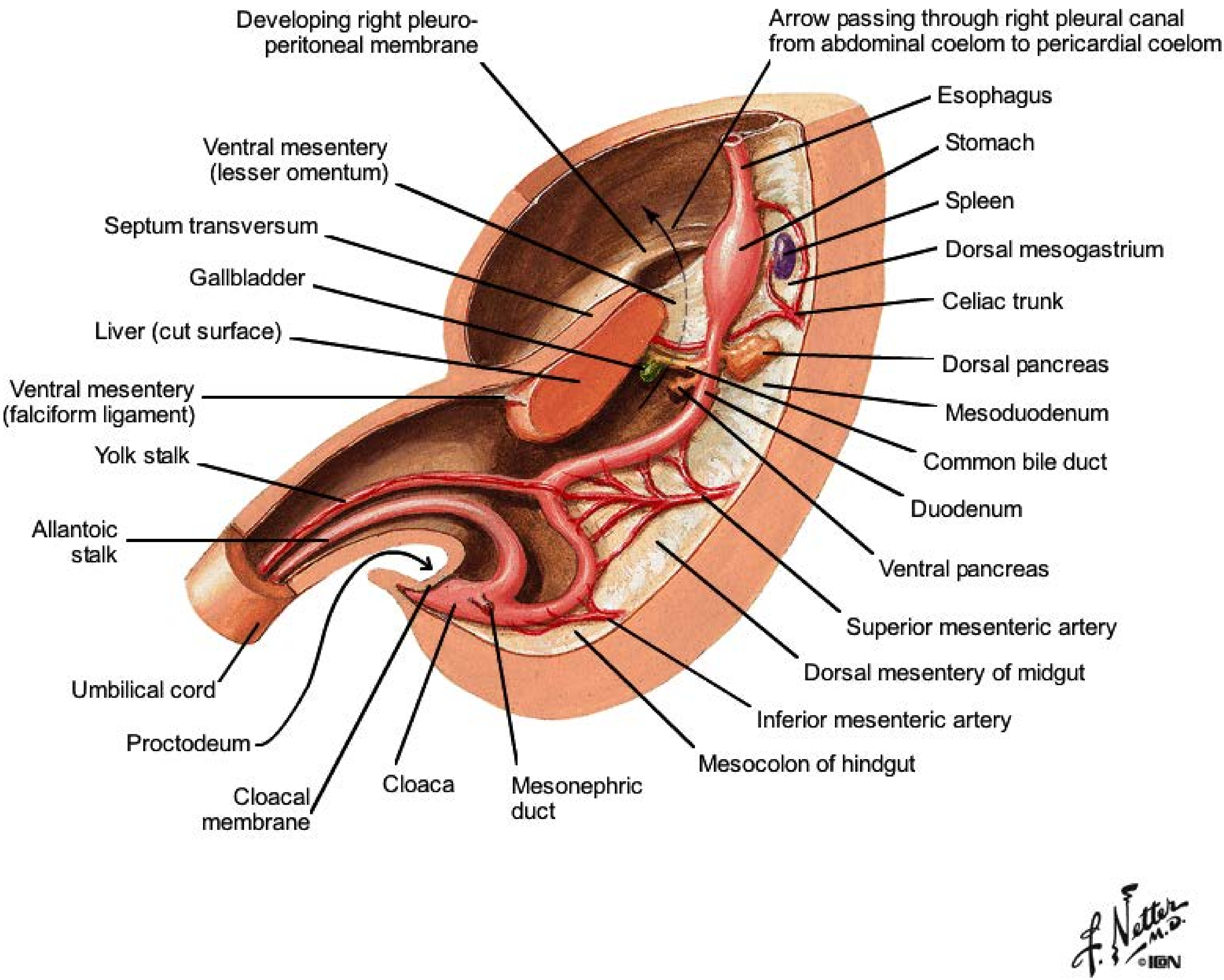


Early Primordia



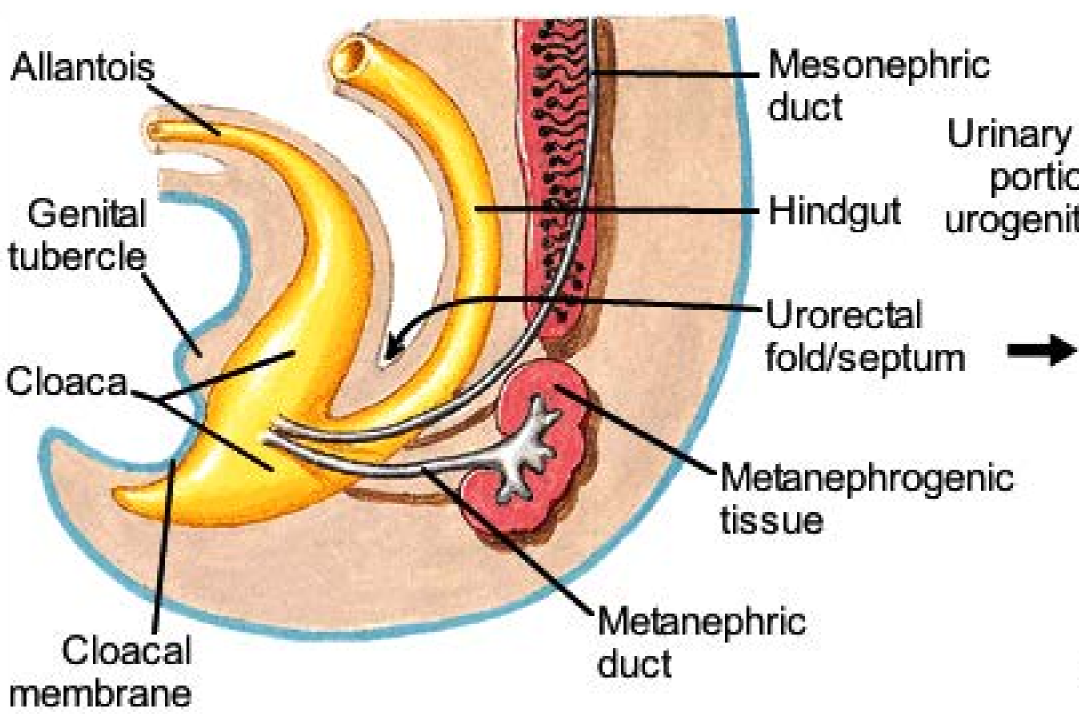
Division of the Cloaca

Abdominal foregut, midgut, and hindgut at 5 weeks

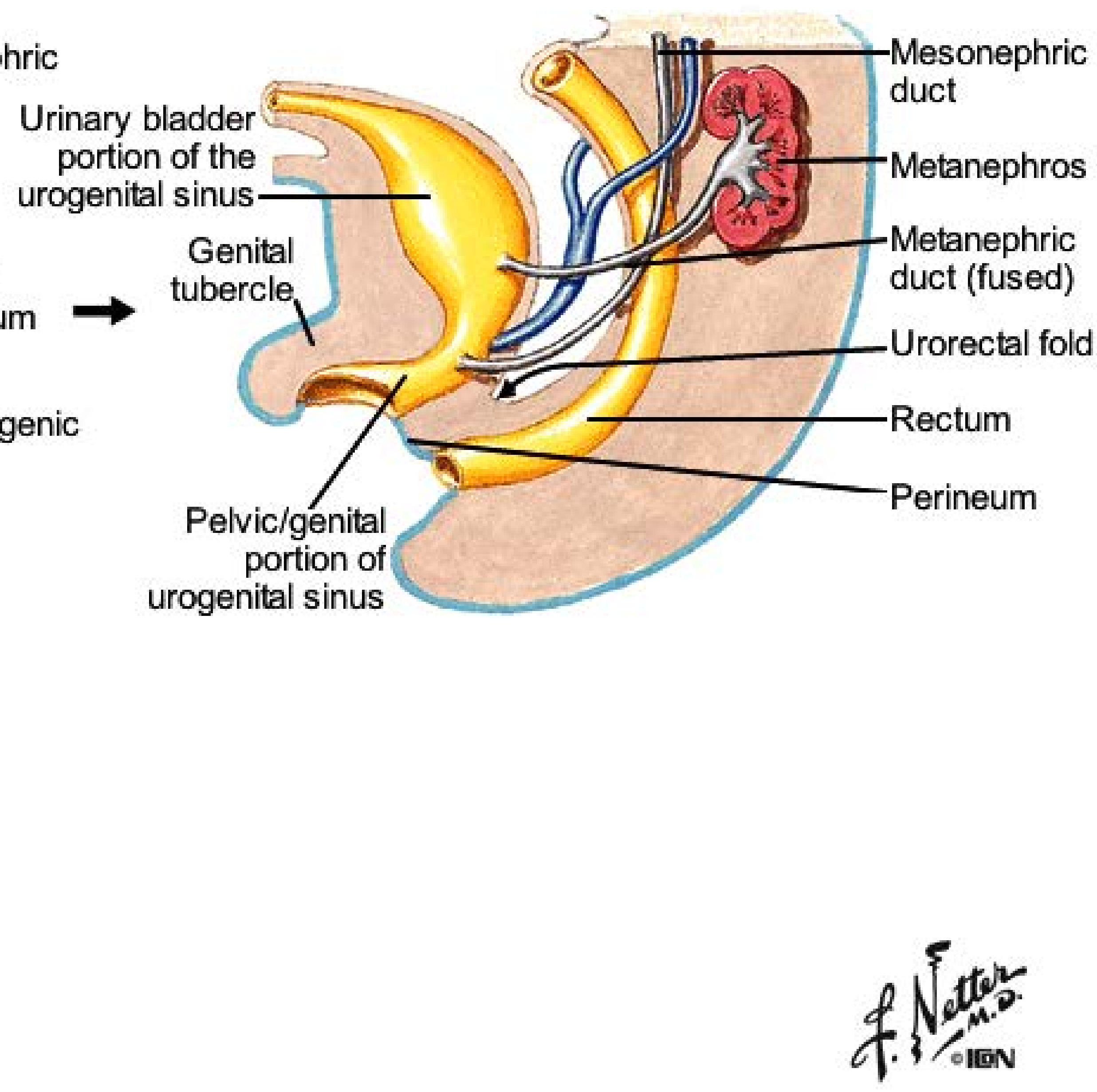


Division of the Cloaca

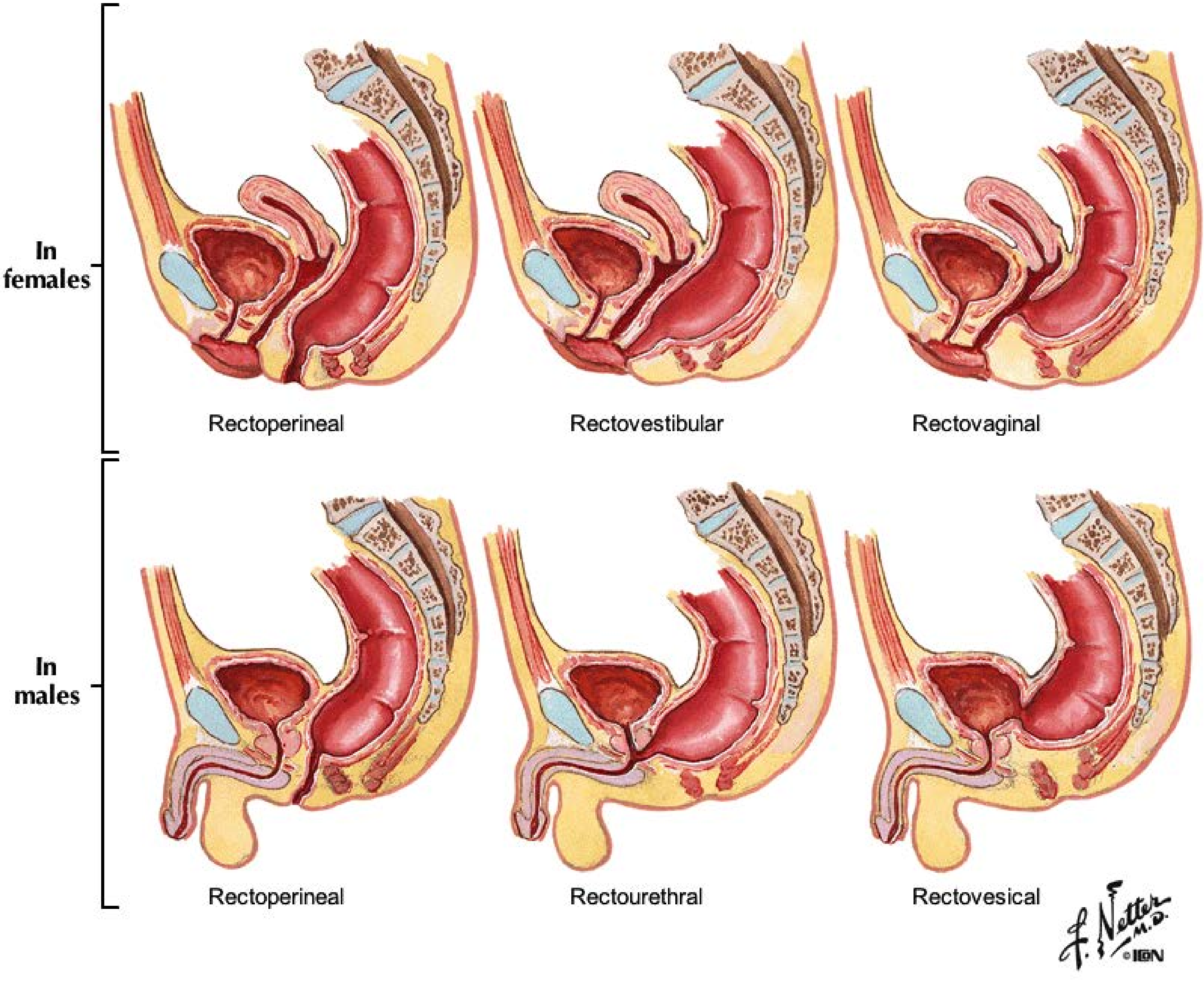
Division of the cloaca by the urorectal septum



Urogenital sinus and rectum

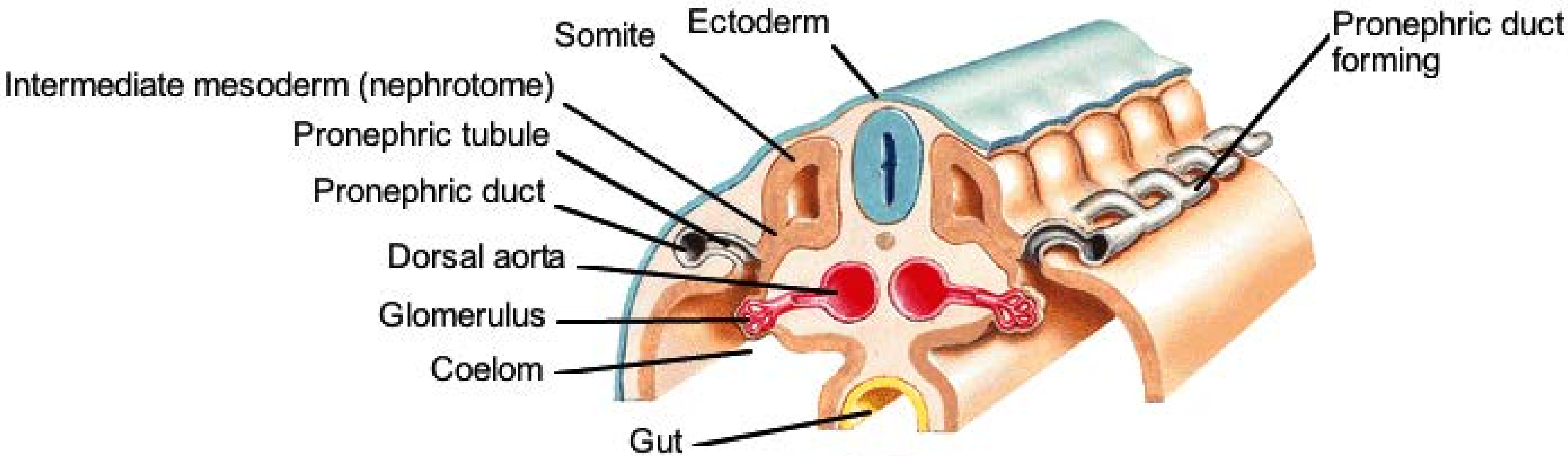


Congenital Cloacal Anomalies
Fistulas resulting from the incomplete division of the cloaca

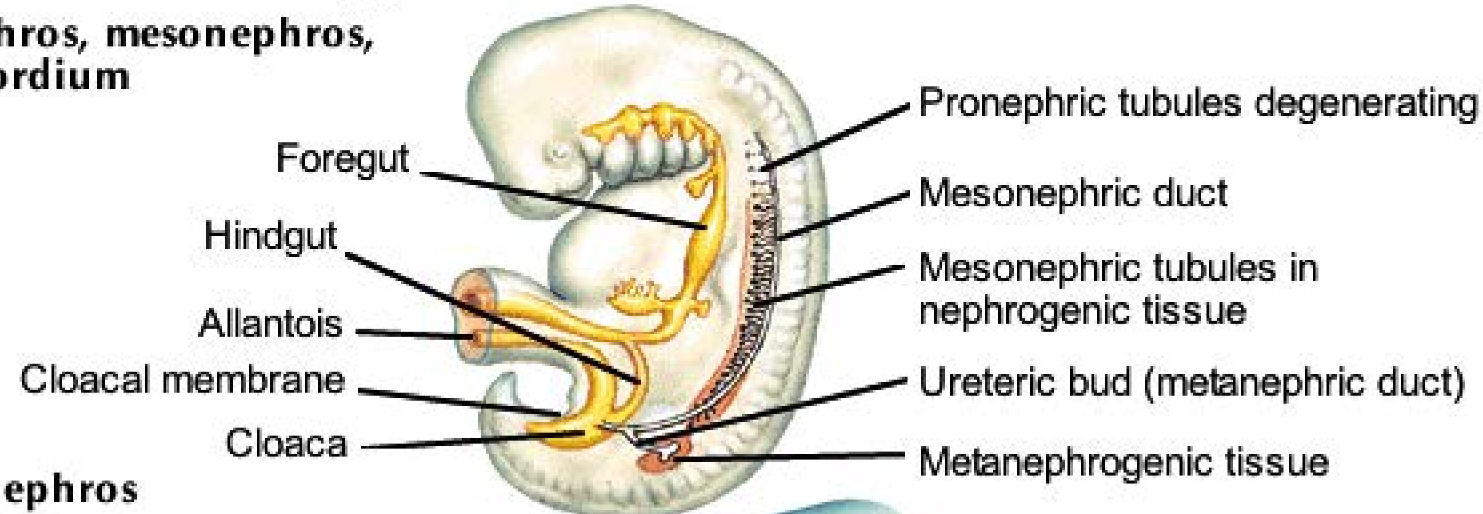


Pronephros, Mesonephros, and Metanephros

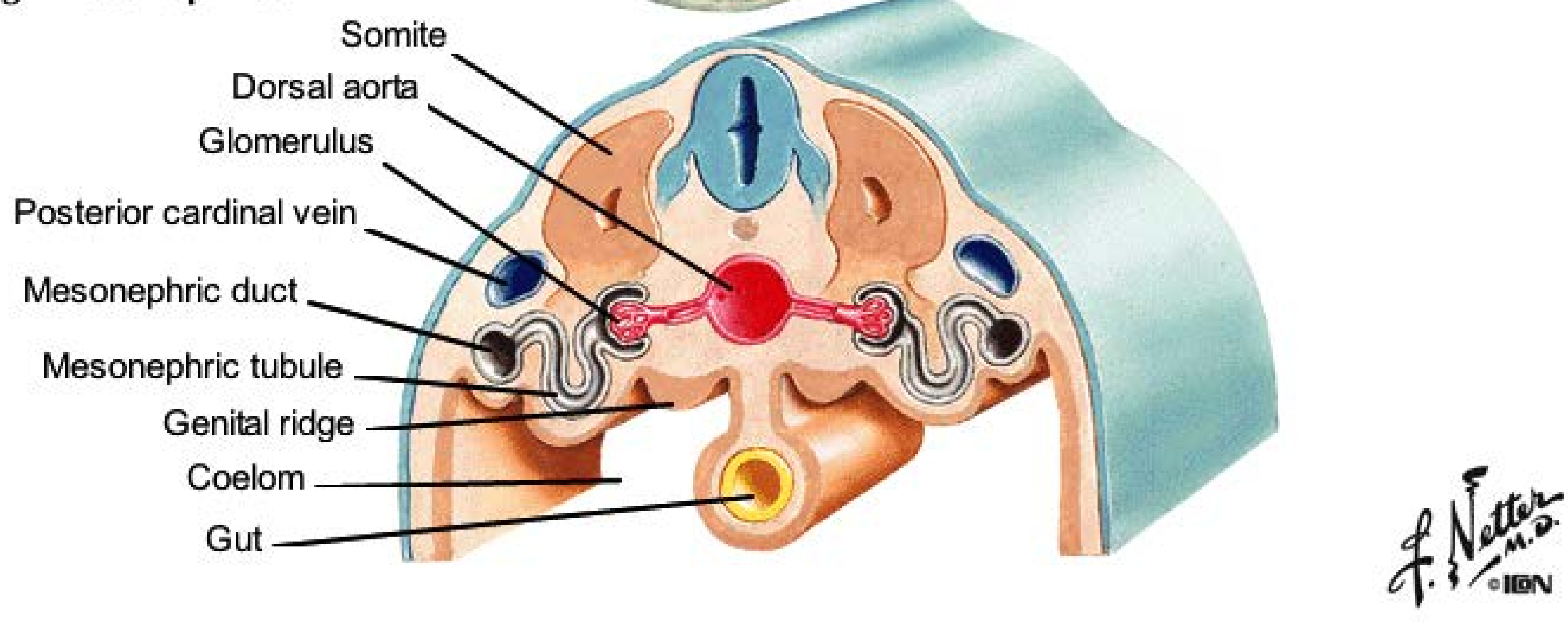
Section through pronephros



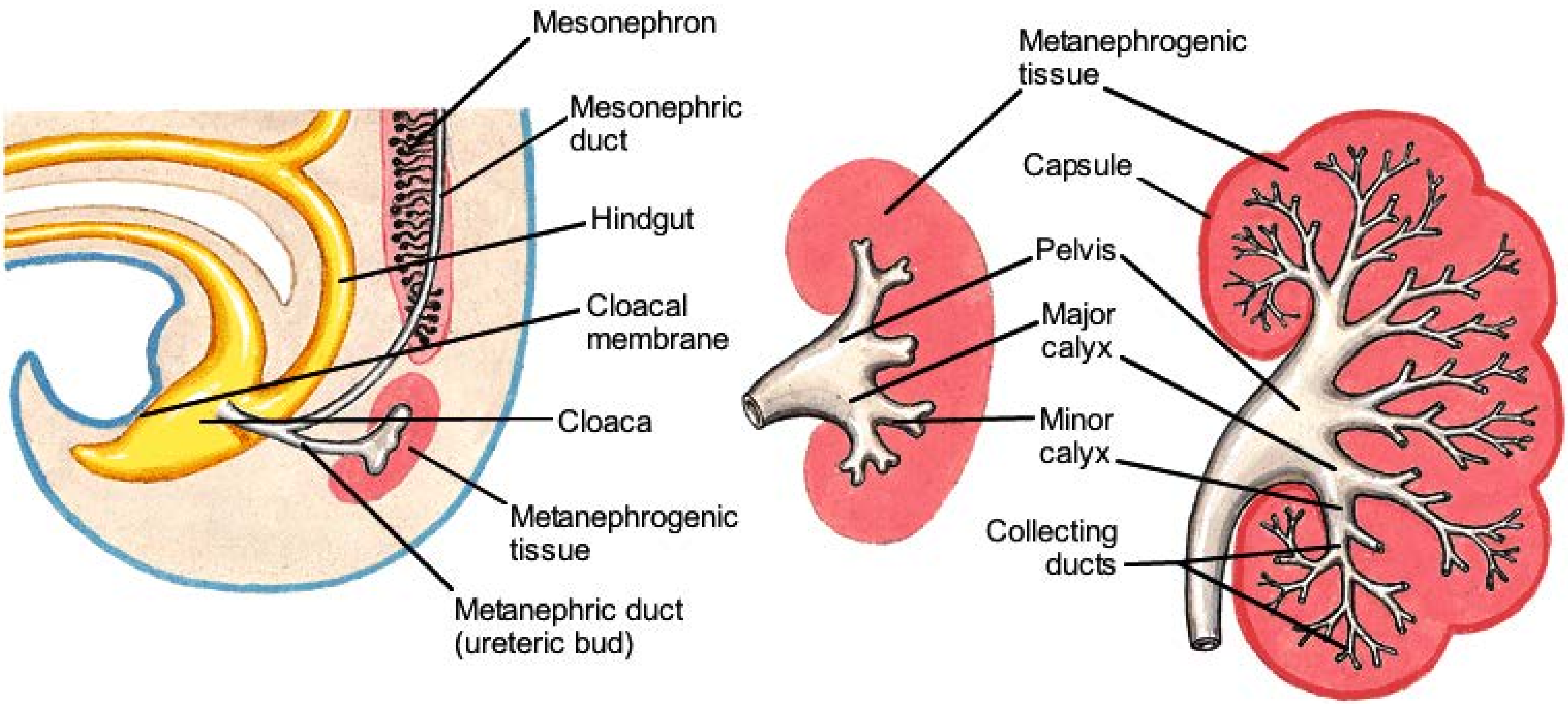
Topography of pronephros, mesonephros, and metanephric primordium



Section through mesonephros



Development of the Metanephros



A. The metanephric duct (ureteric bud) has grown out from the mesonephric duct, close to termination of latter in cloaca, and has invaded the metanephrogenic mesoderm.

B. Within the metanephrogenic tissue, the ureteric bud expands to form a pelvis, which branches into calyces, and these, in turn, bud into successive generations of collecting ducts.

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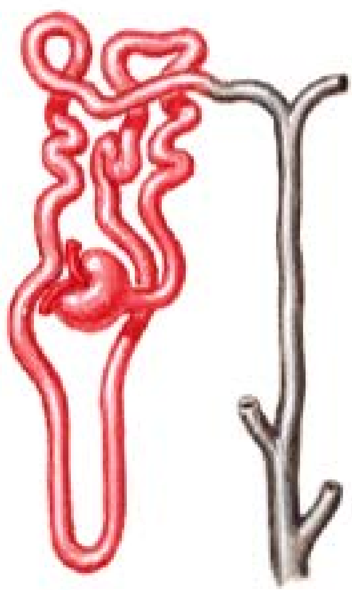
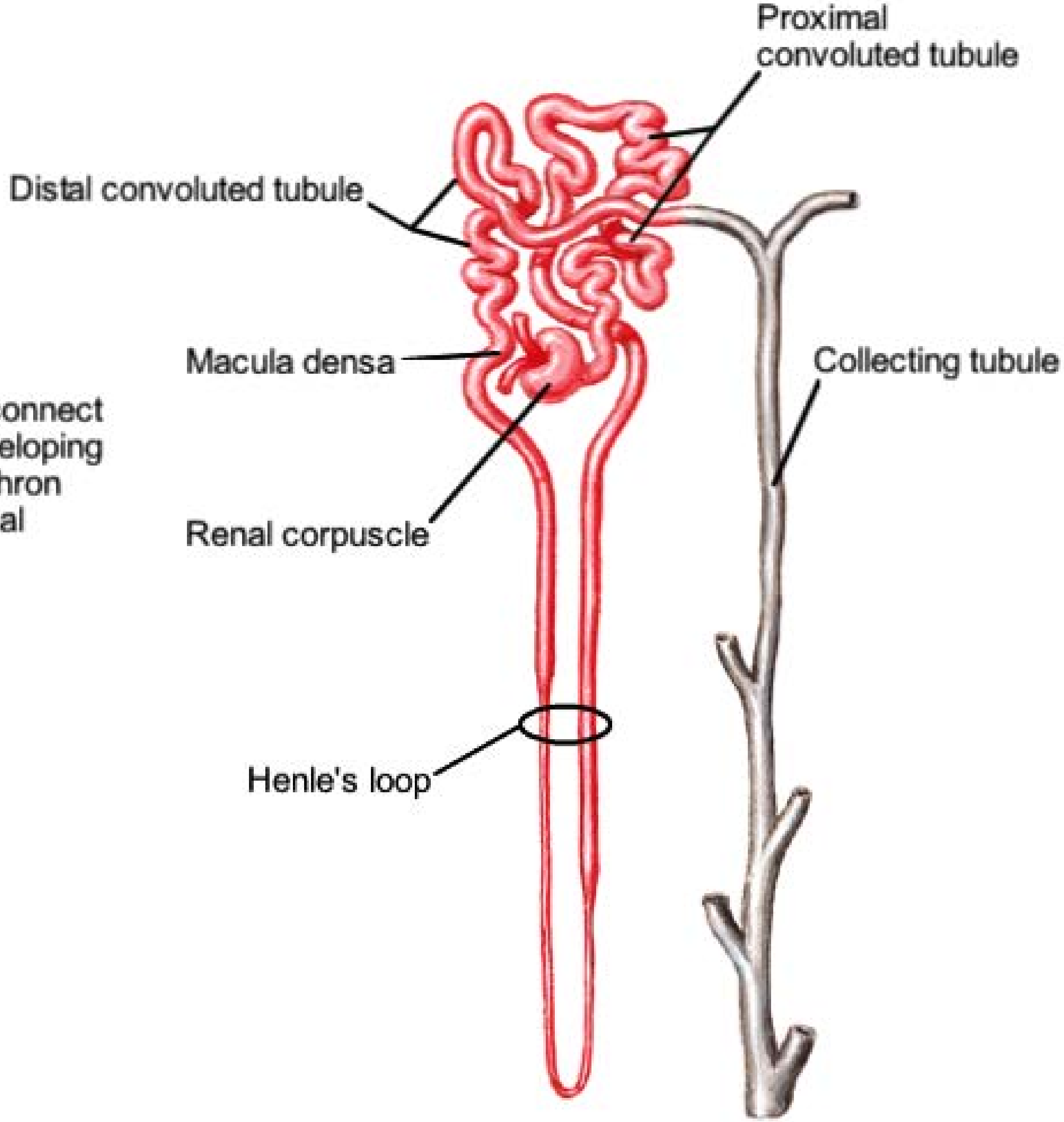
Development of the Metanephros

C. The distal ends of the collecting ducts connect with the tubule system of the nephron developing from the metanephric mesoderm. The nephron extends from the collecting duct to the renal corpuscle.



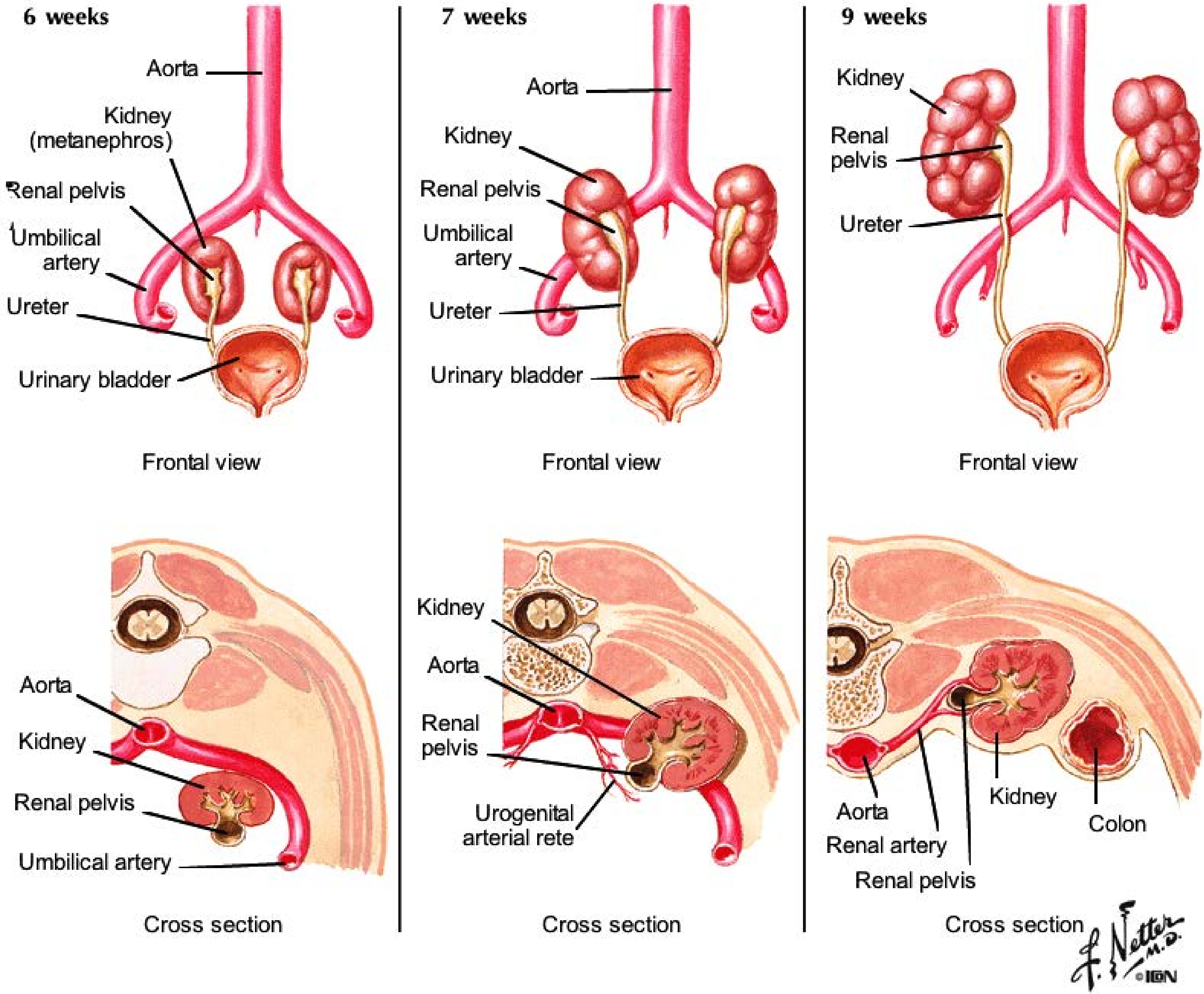
D. The tubule lengthens, coils, and begins to dip down toward the renal pelvis, as Henle's loop; one area of the tubule remains close to the glomerular mouth, as the future macula densa.



E. The loop elongates; renal corpuscle, proximal tubule, Henle's loop, distal tubule, and macula densa of mature nephron are thus derived from metanephrogenic mesoderm and collecting tubules from the metanephric duct.

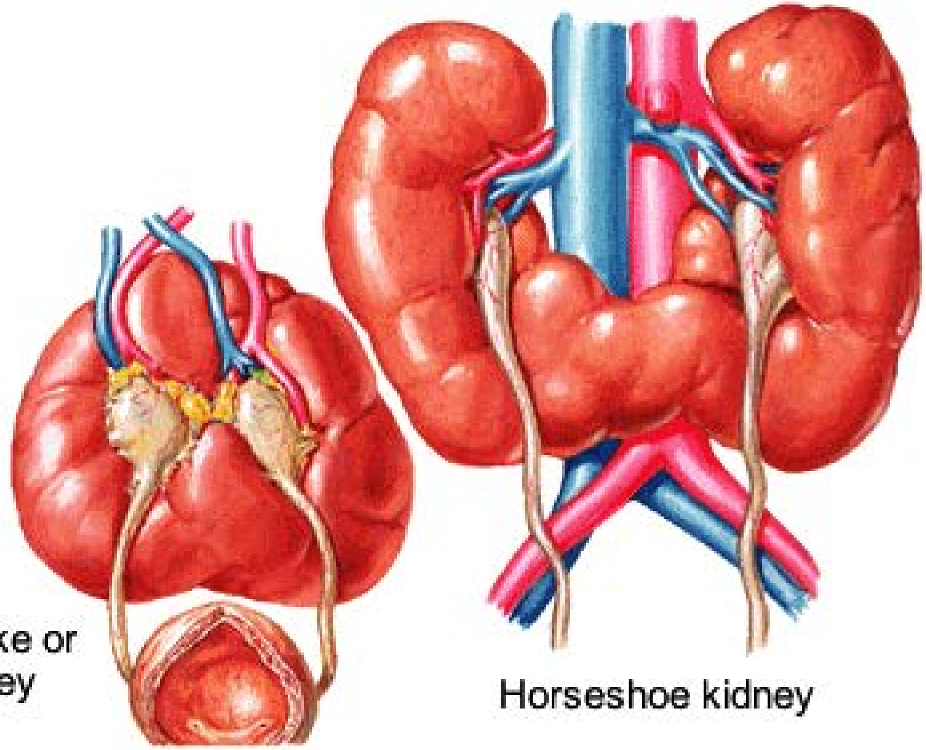
Ascent and Rotation of the Metanephric Kidneys

Apparent "ascent and rotation" of the kidneys in embryological development

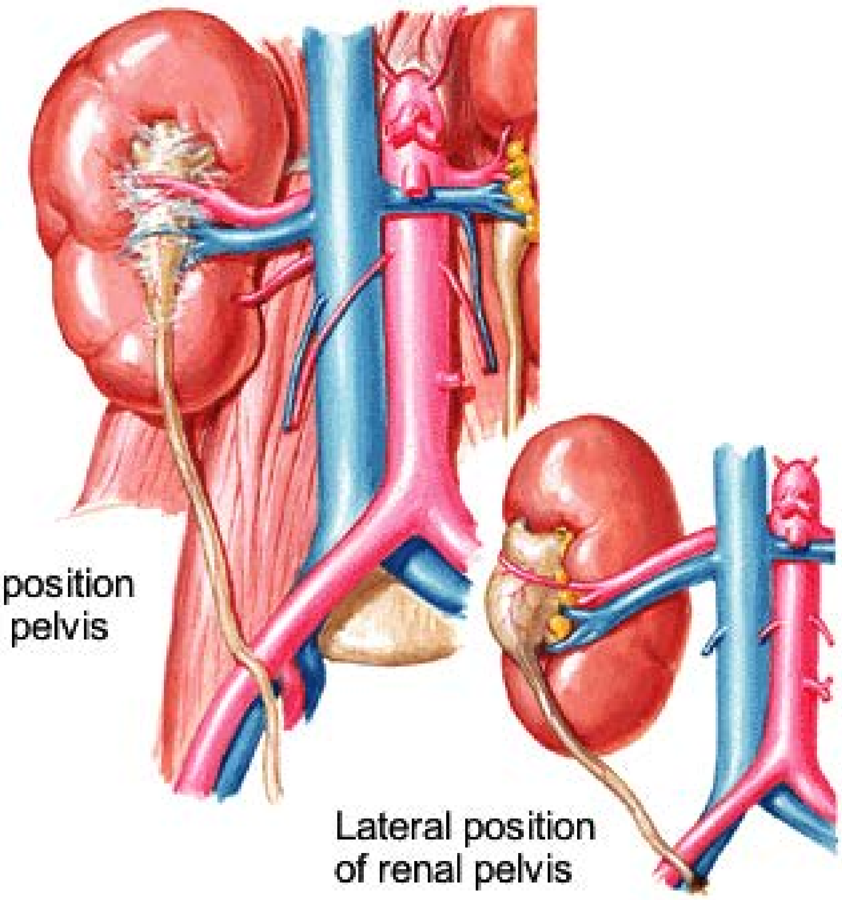


Kidney Rotation and Migration Anomalies

Renal fusion

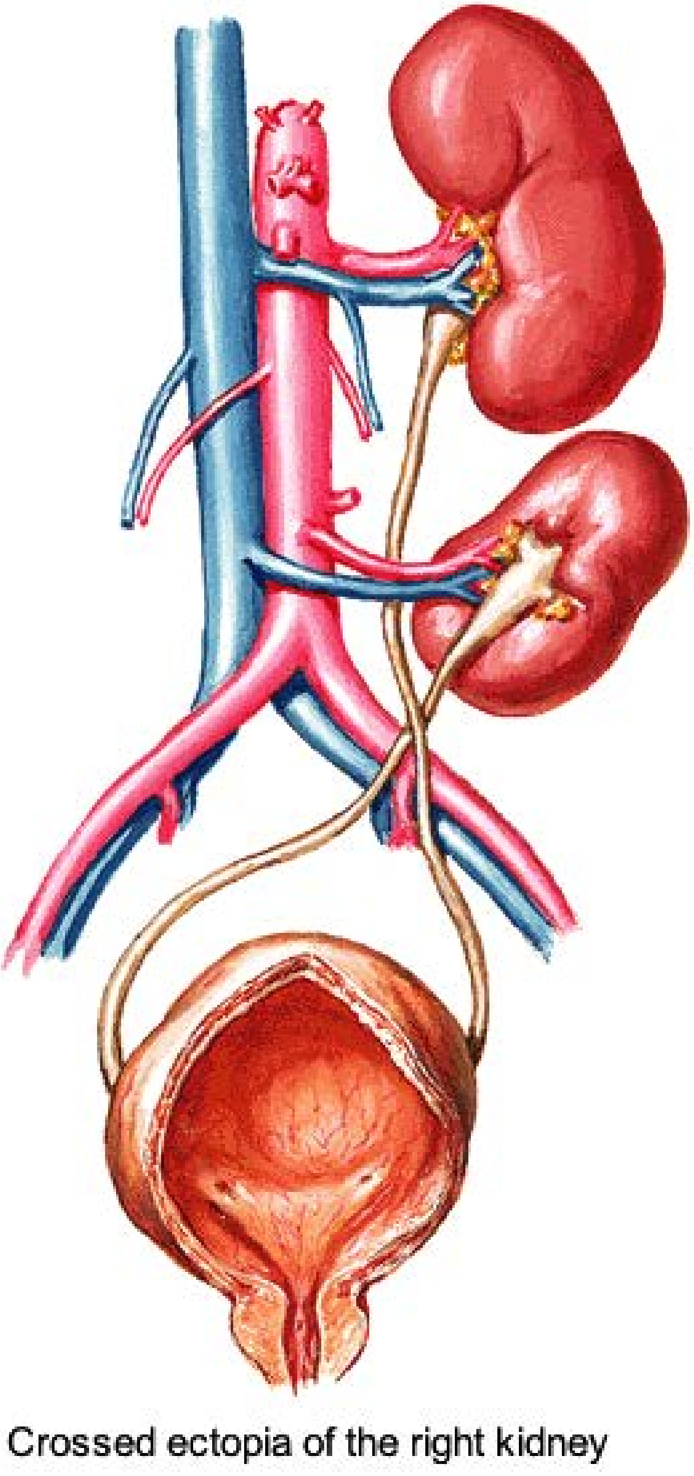


Anomalies of renal rotation

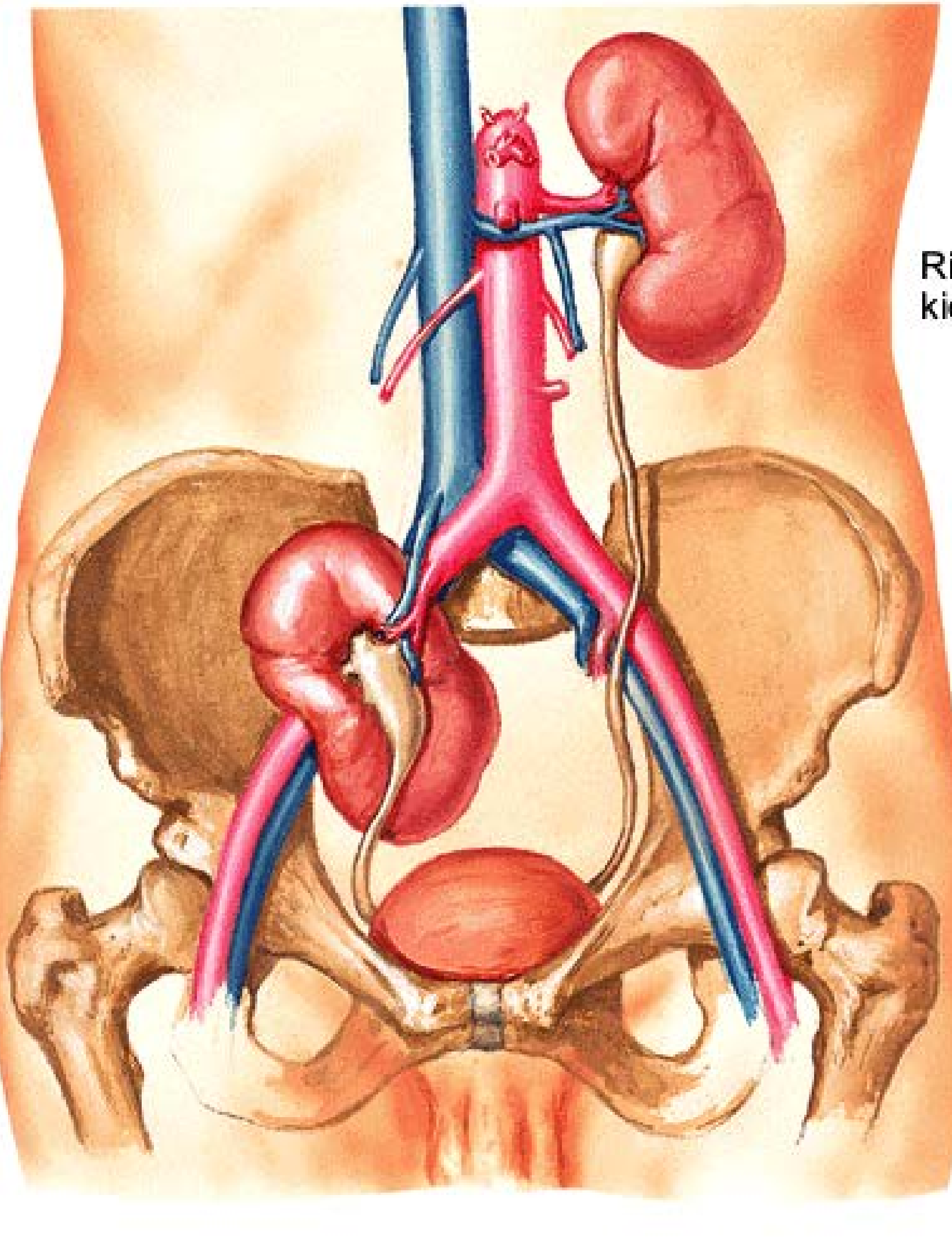


Kidney Rotation and Migration Anomalies

Ectopia of the kidney

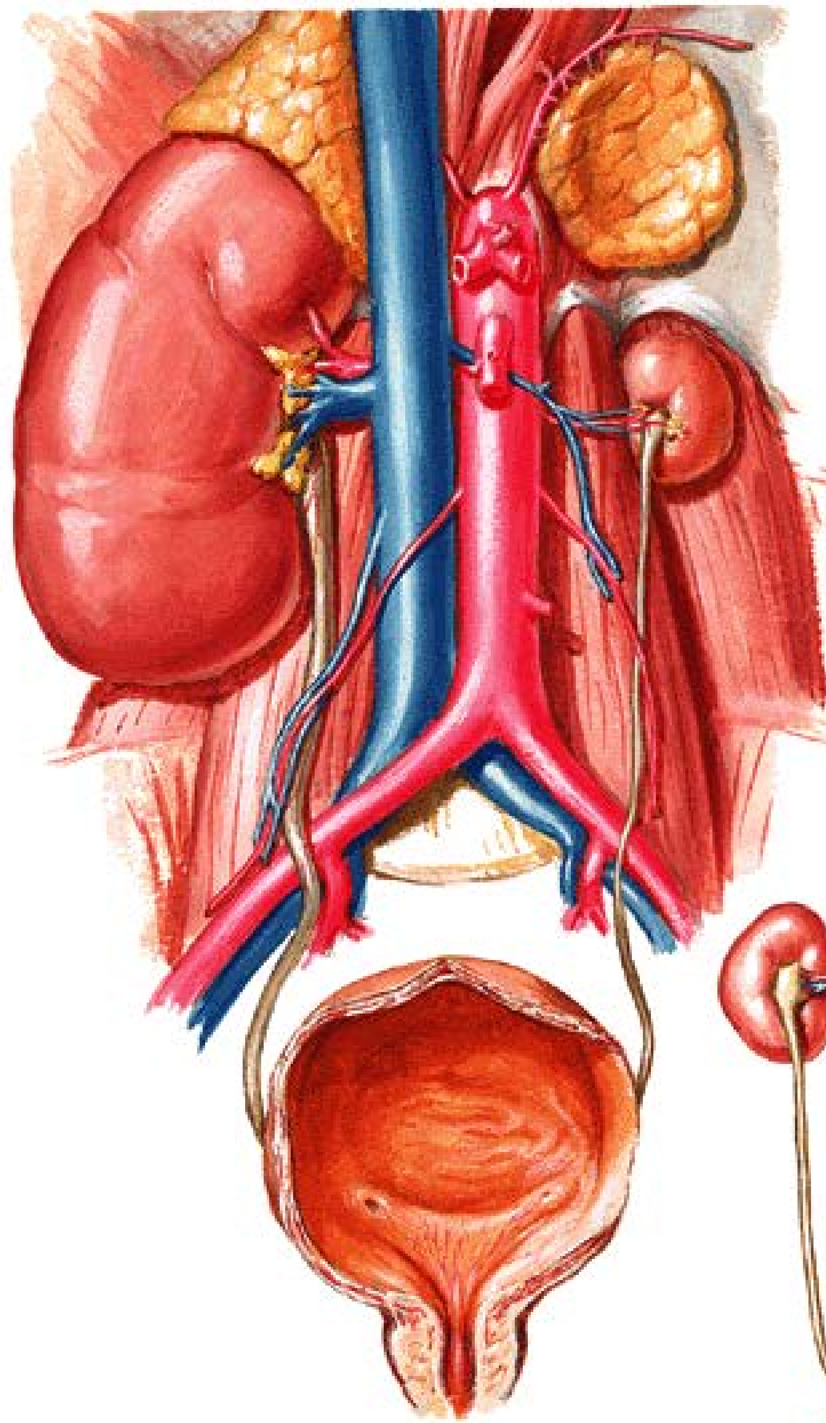


Crossed ectopia of the right kidney

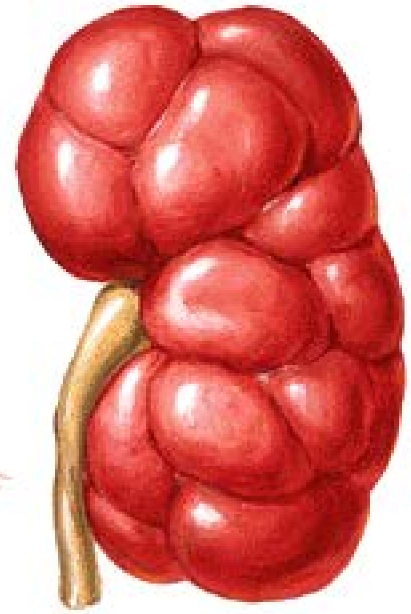


Right pelvic kidney

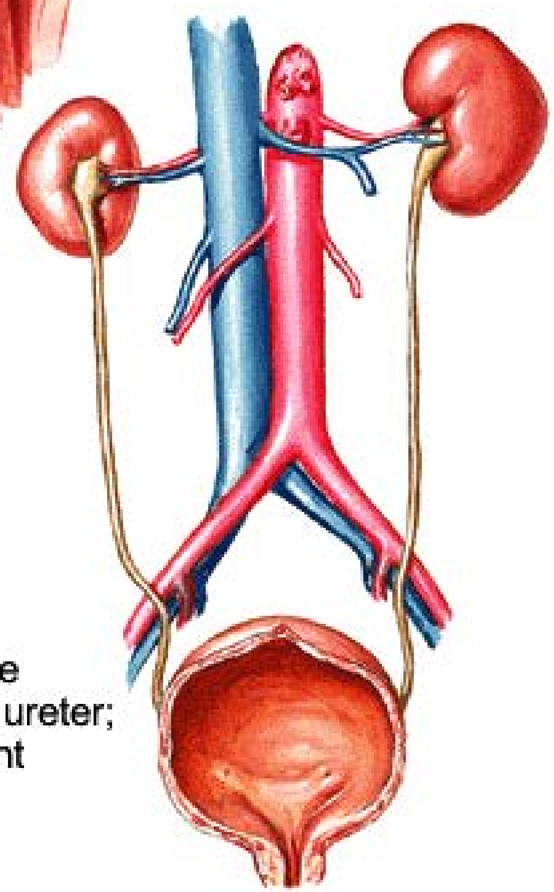
Hypoplasia



Left unilateral hypoplasia of the kidney with narrow but patent ureter; both suprarenal glands present



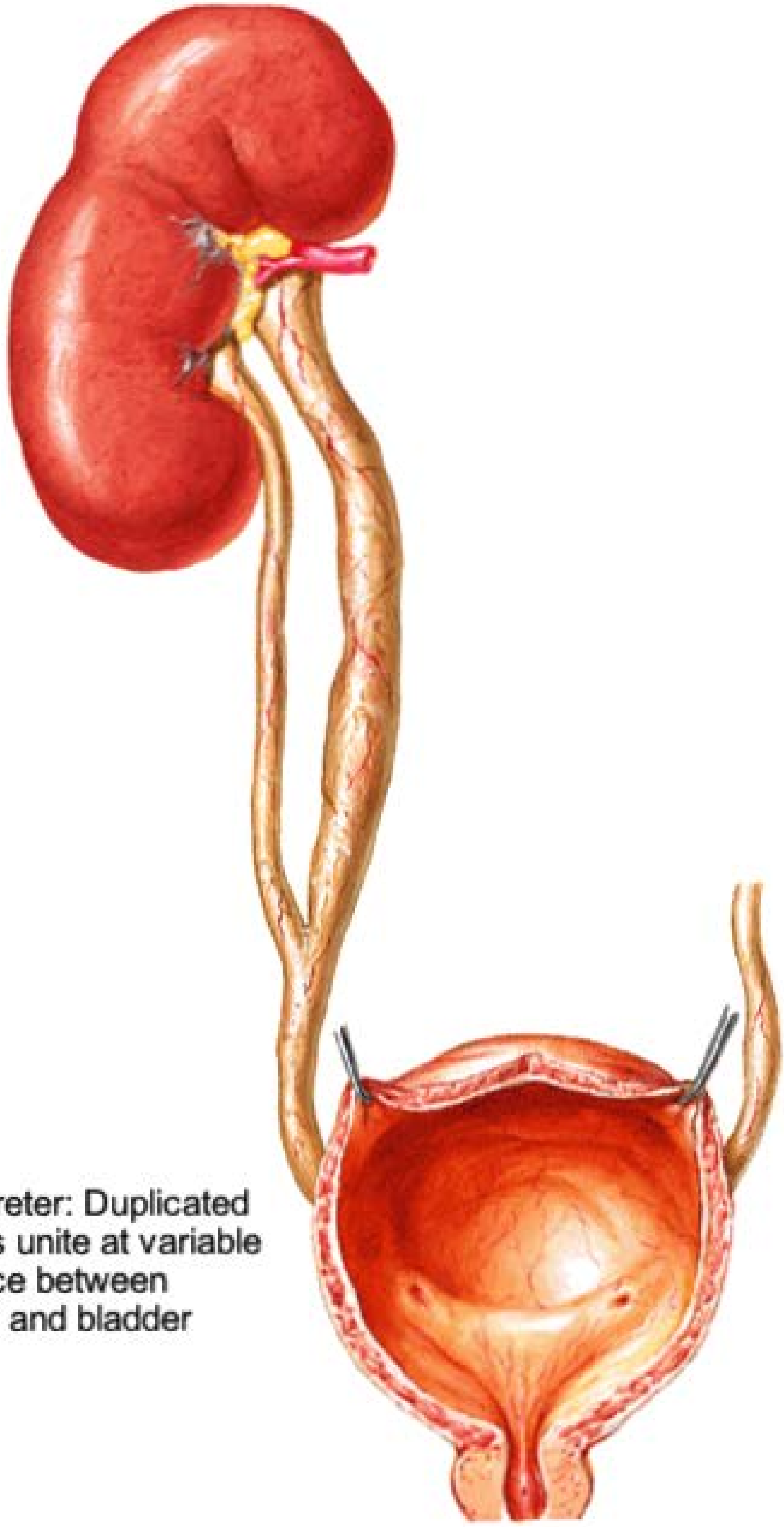
Persistent fetal lobulation



Bilateral renal hypoplasia

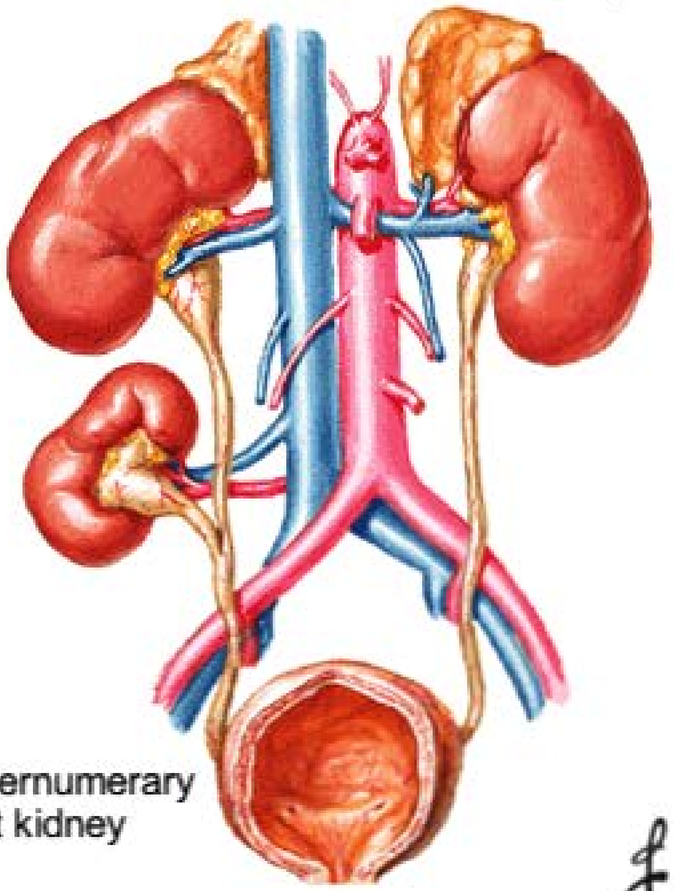
Ureteric Bud Duplication

Incomplete duplication of ureter

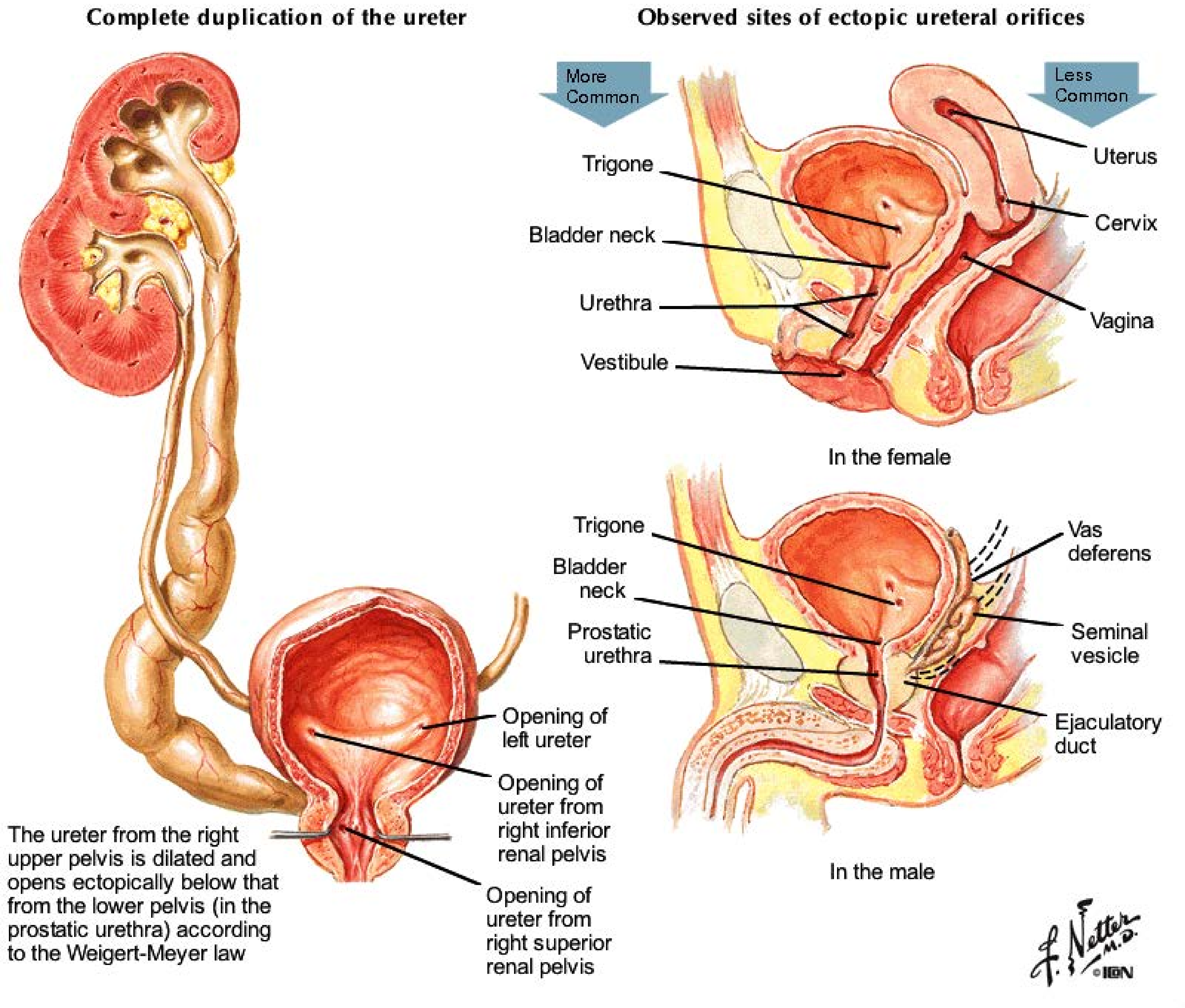


Anomalies of renal pelvis and calyces

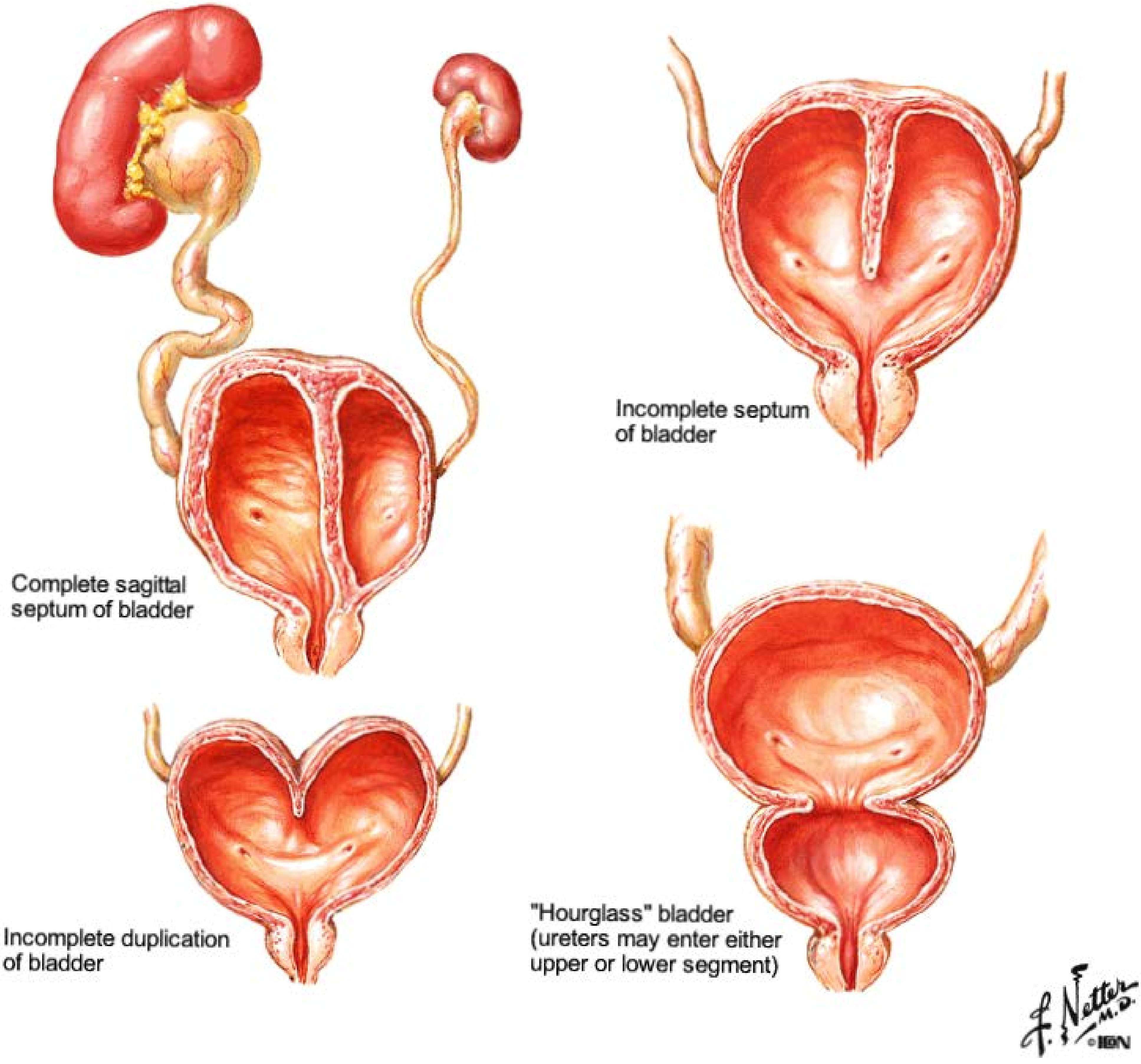
Anomalies in number of kidneys



Ectopic Ureters



Bladder Anomalies

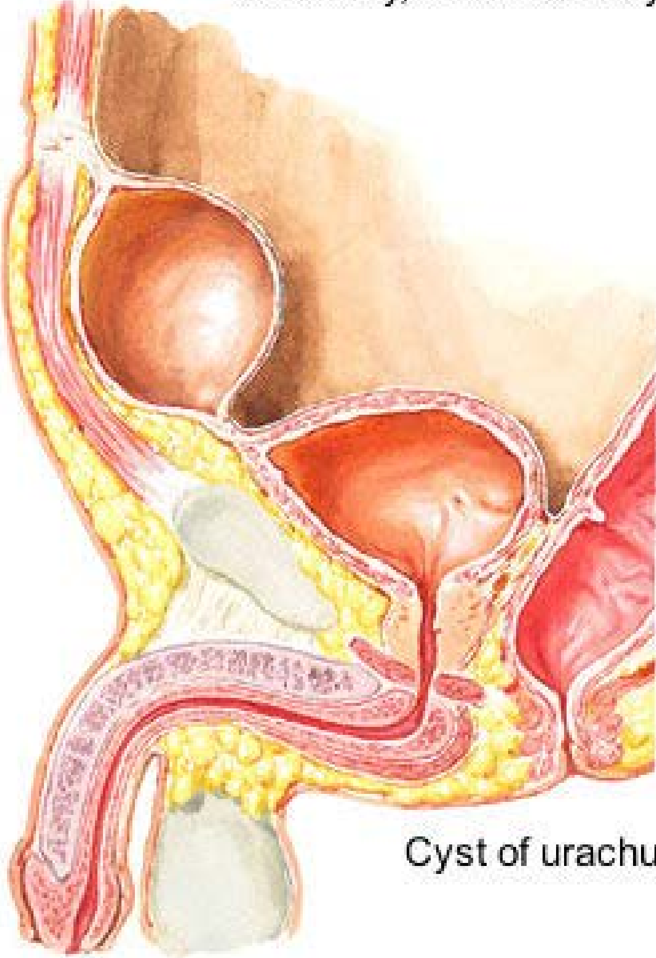


Allantois/Urachus Anomalies

Completely patent urachus

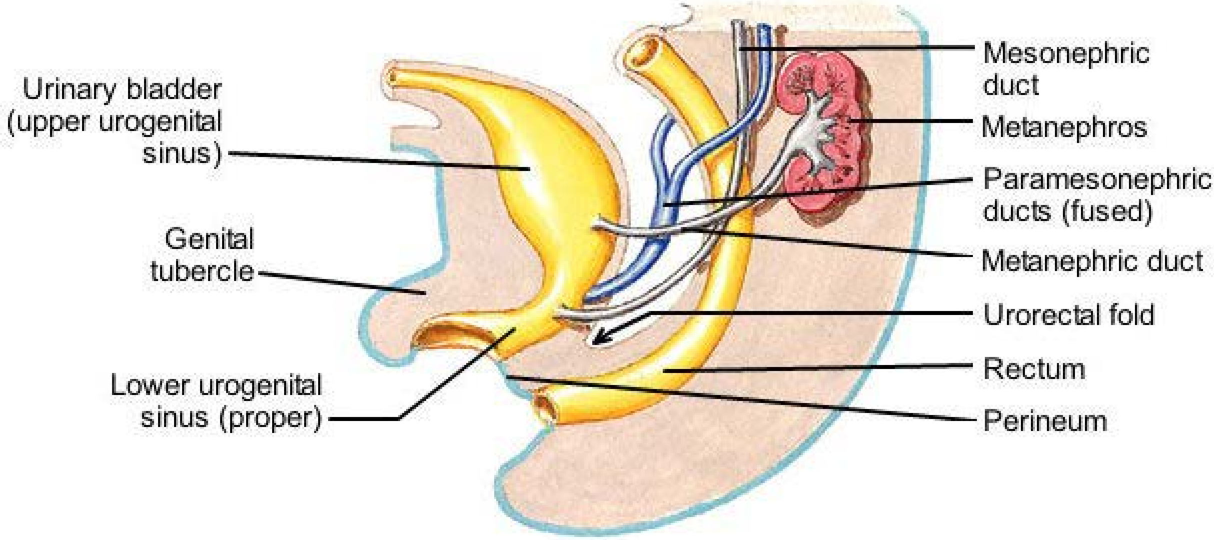
Partially patent urachus; opening externally, blind internally

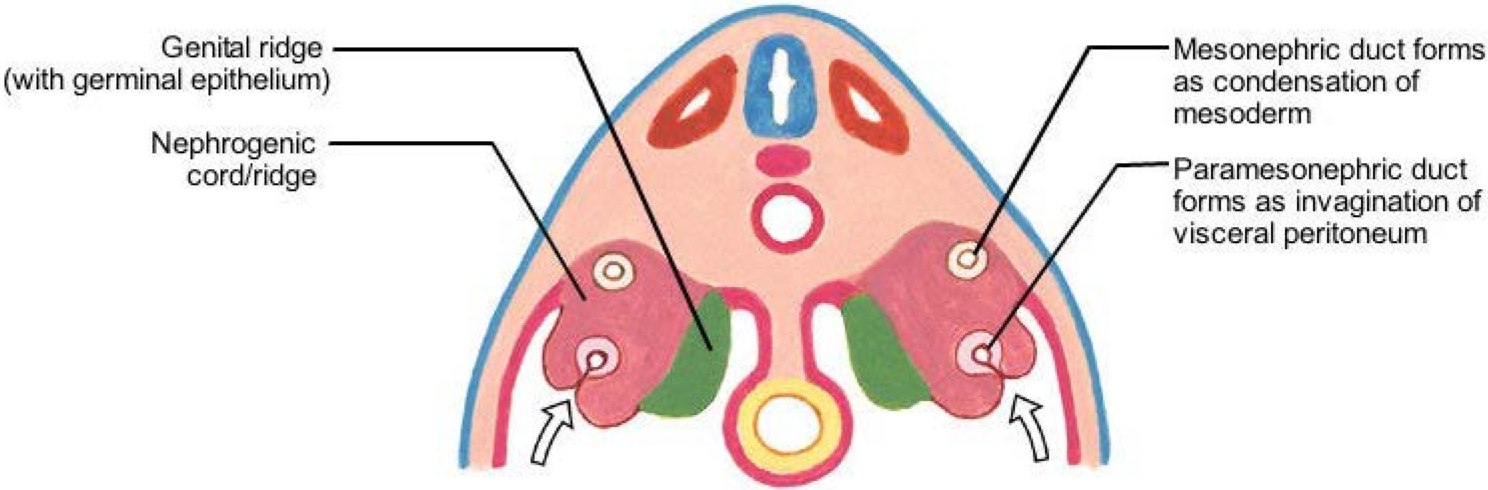
Partially patent urachus; opening internally, blind externally



Cyst of urachus

Primordia of the Genital System





Urogenital ridge differentiates into medial genital ridge and a lateral nephrogenic ridge

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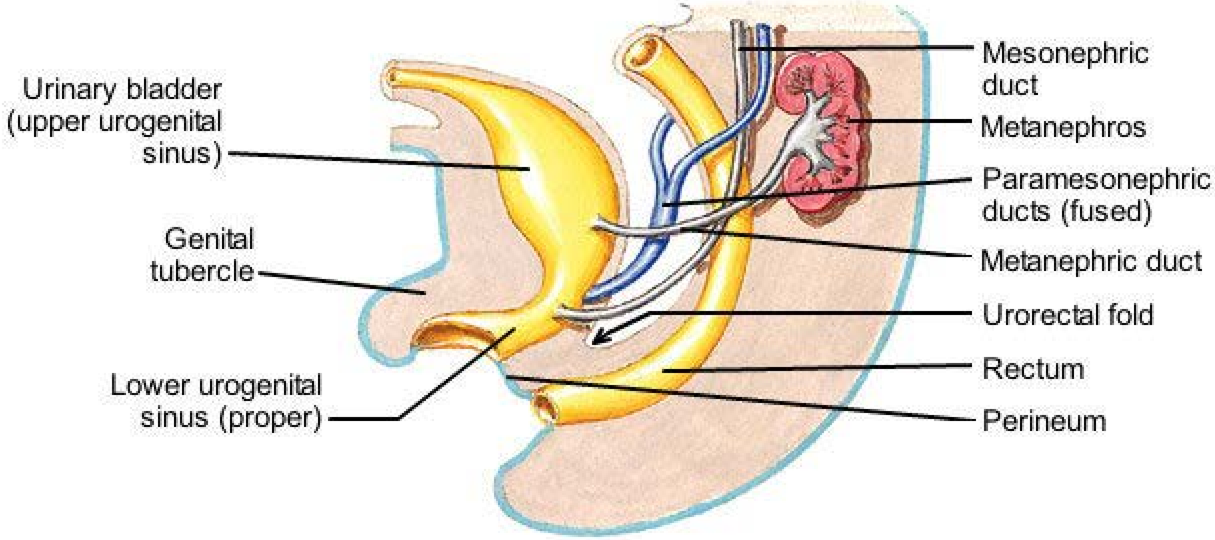
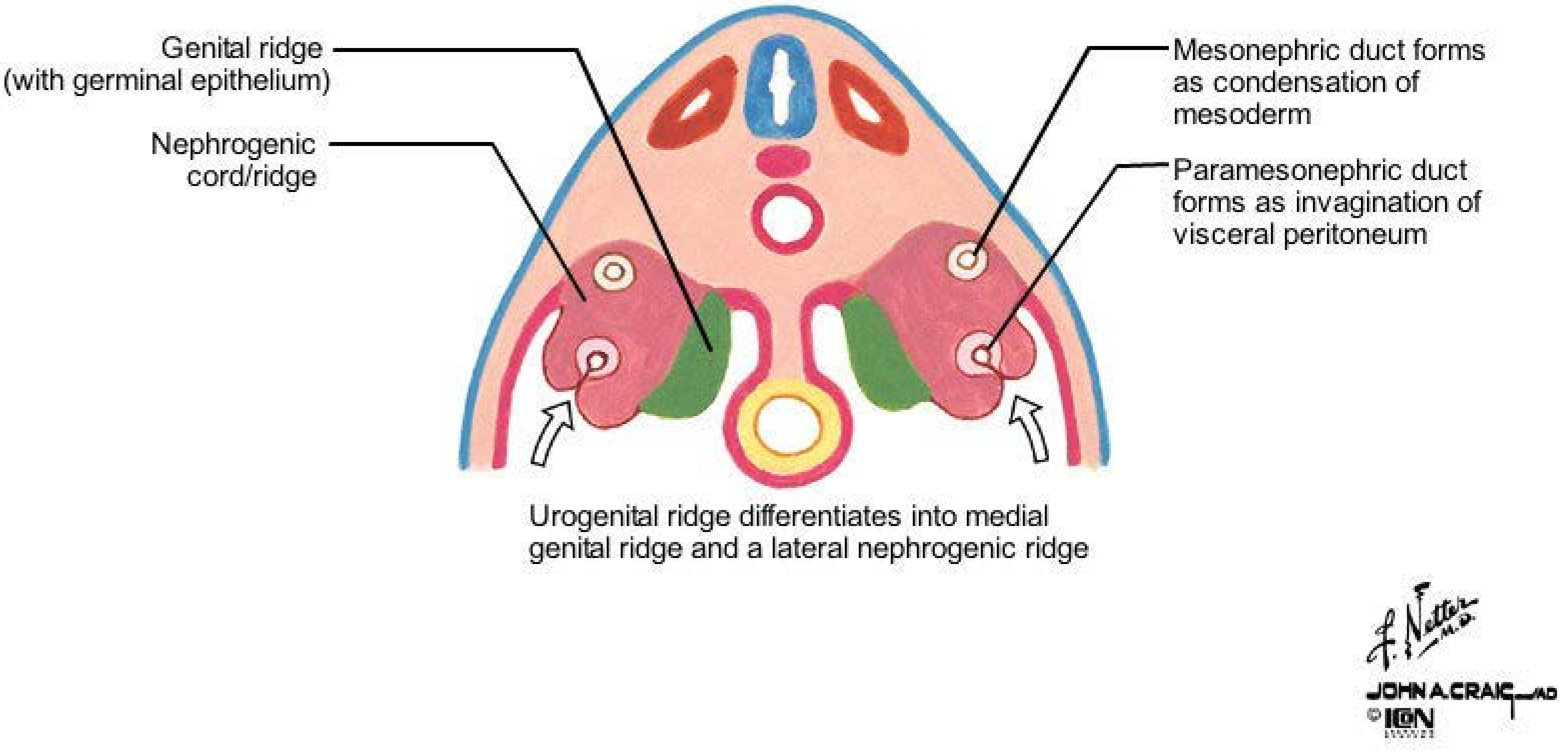
JOHN A. CRAIG MD

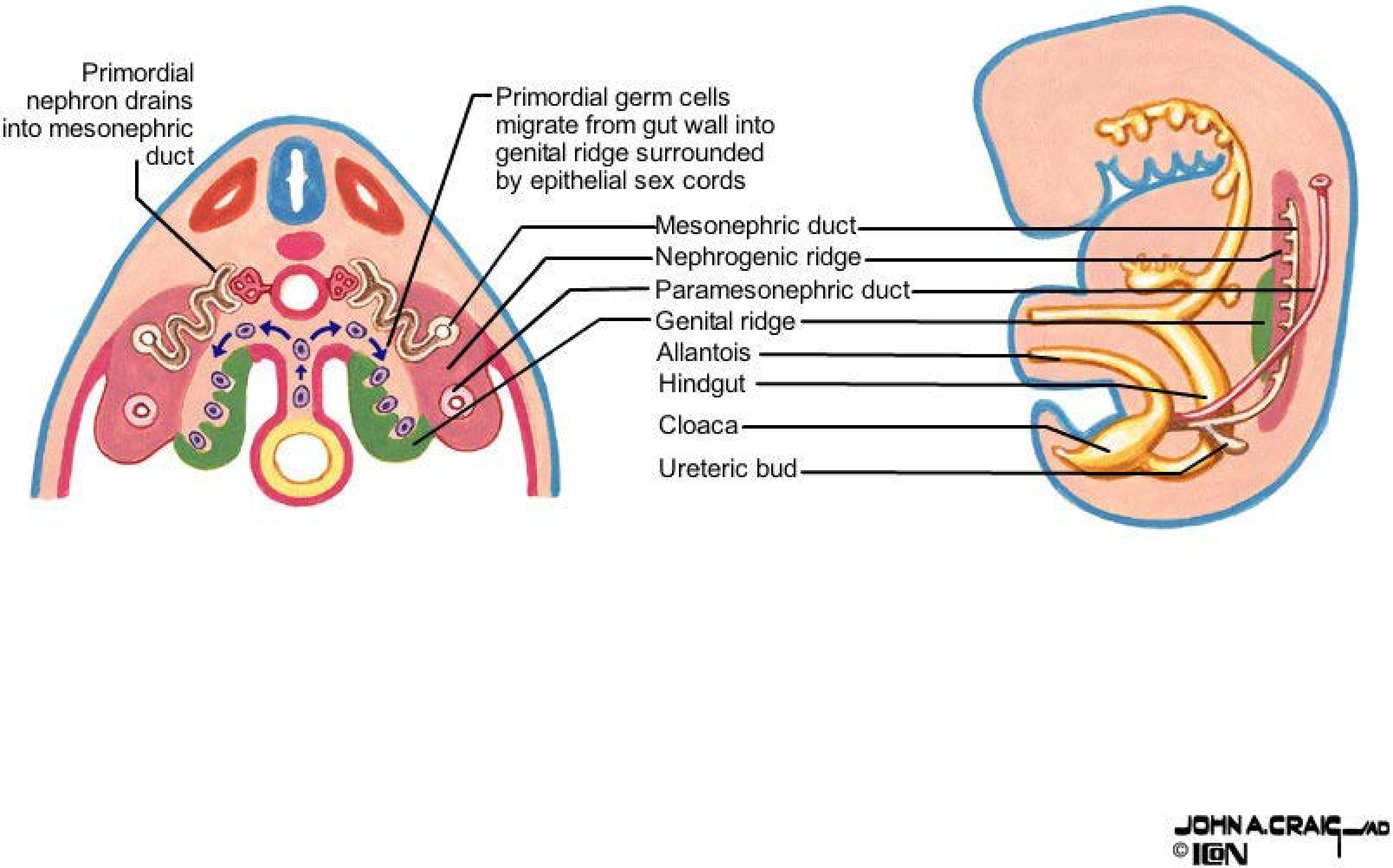
Primordia of the Genital System





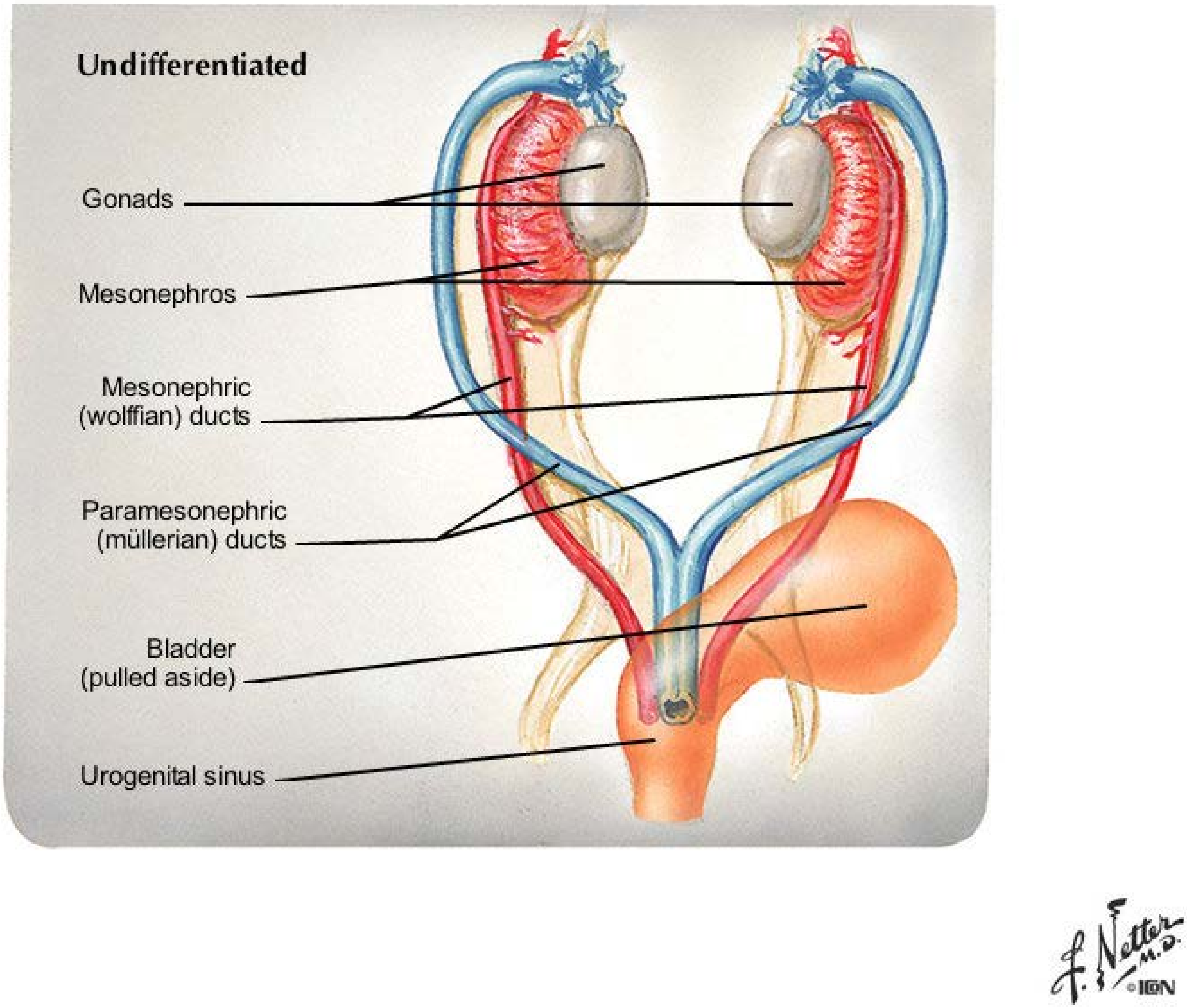
Urogenital ridge differentiates into medial genital ridge and a lateral nephrogenic ridge

Early Primordia



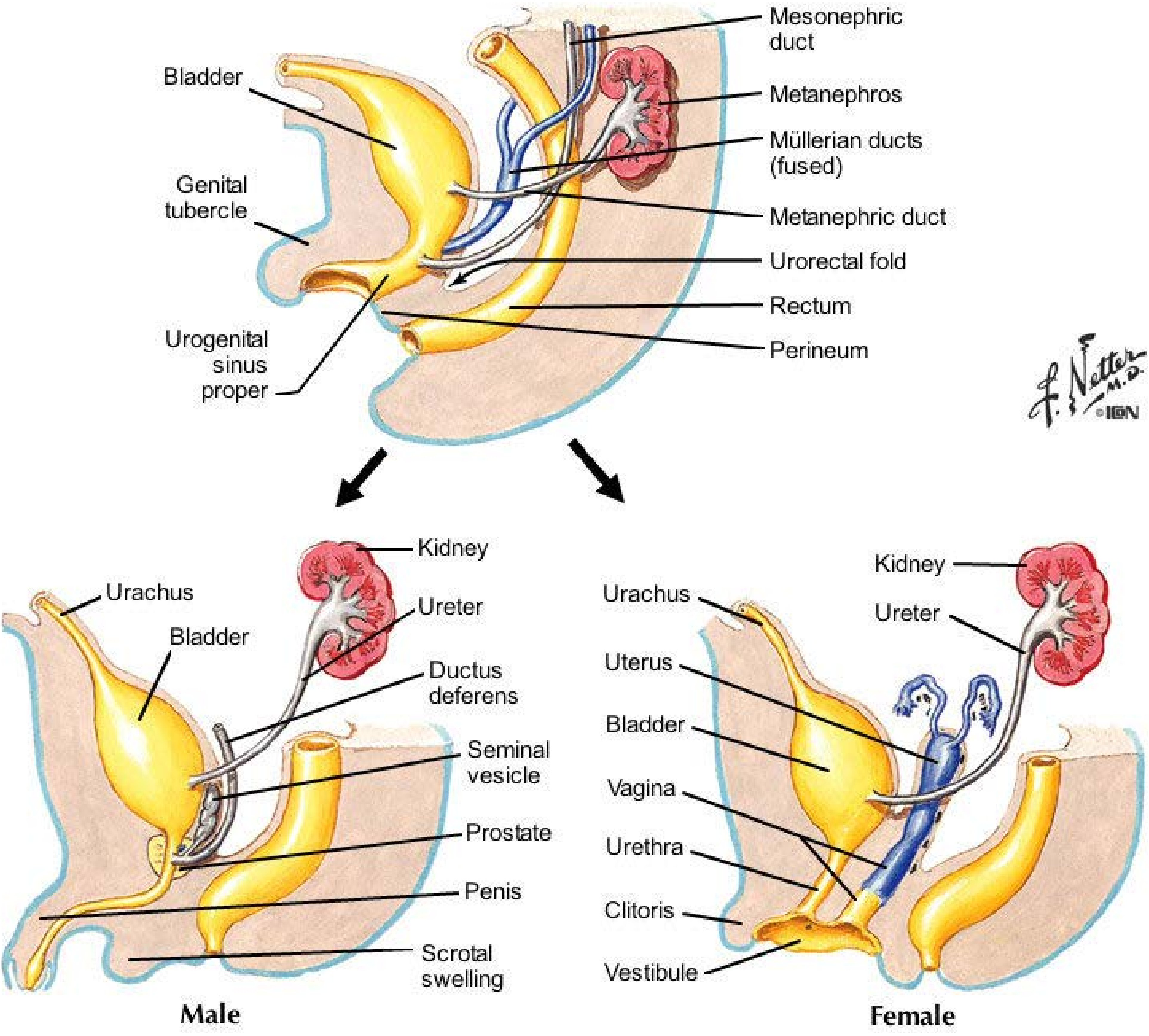
8-Week Undifferentialed (Indifferent) Stage

Anterior view (mesonephros will disappear in both sexes)

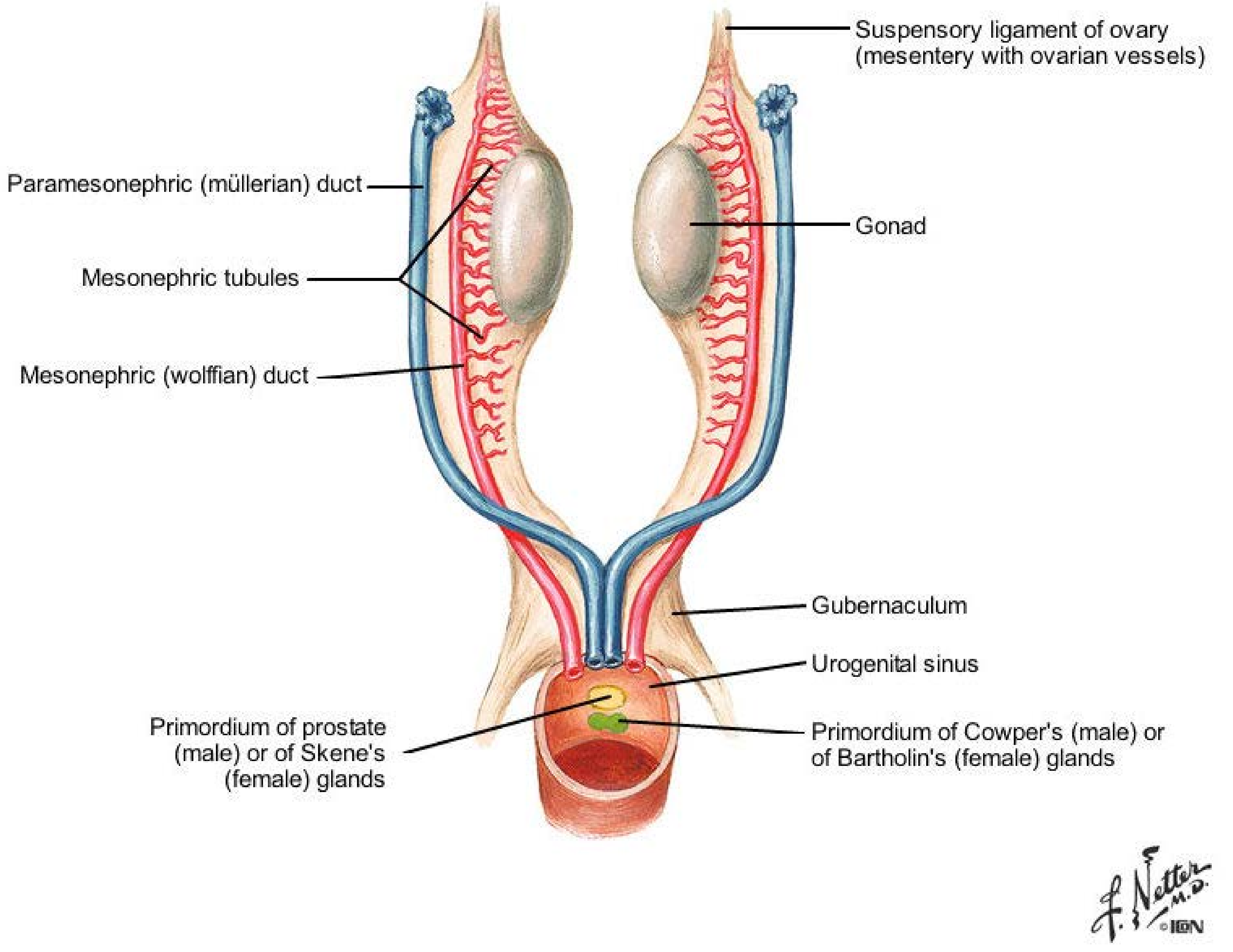


8-Week Undifferentialed (Indifferent) Stage

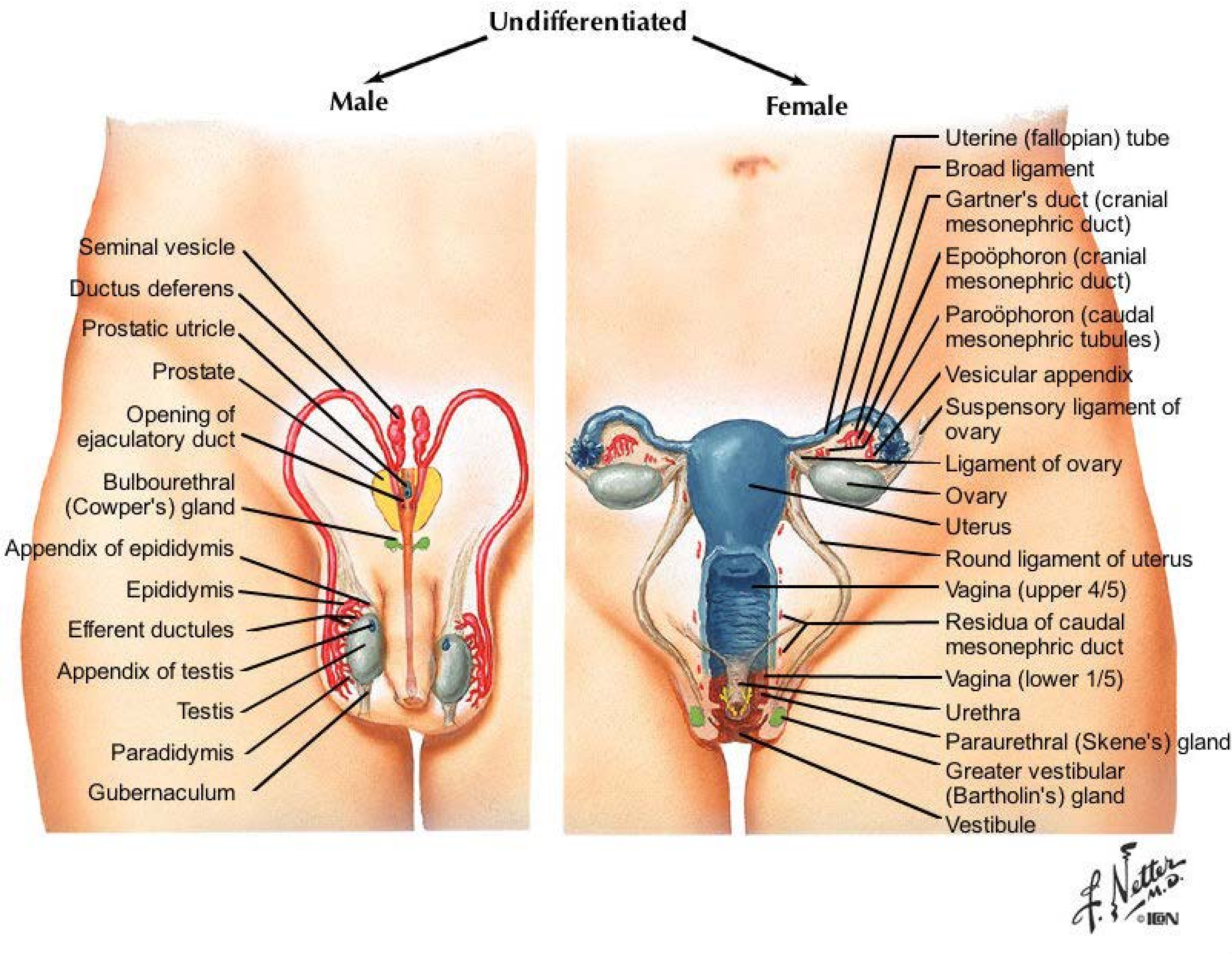
Lateral view (both sexes have identical primordia)



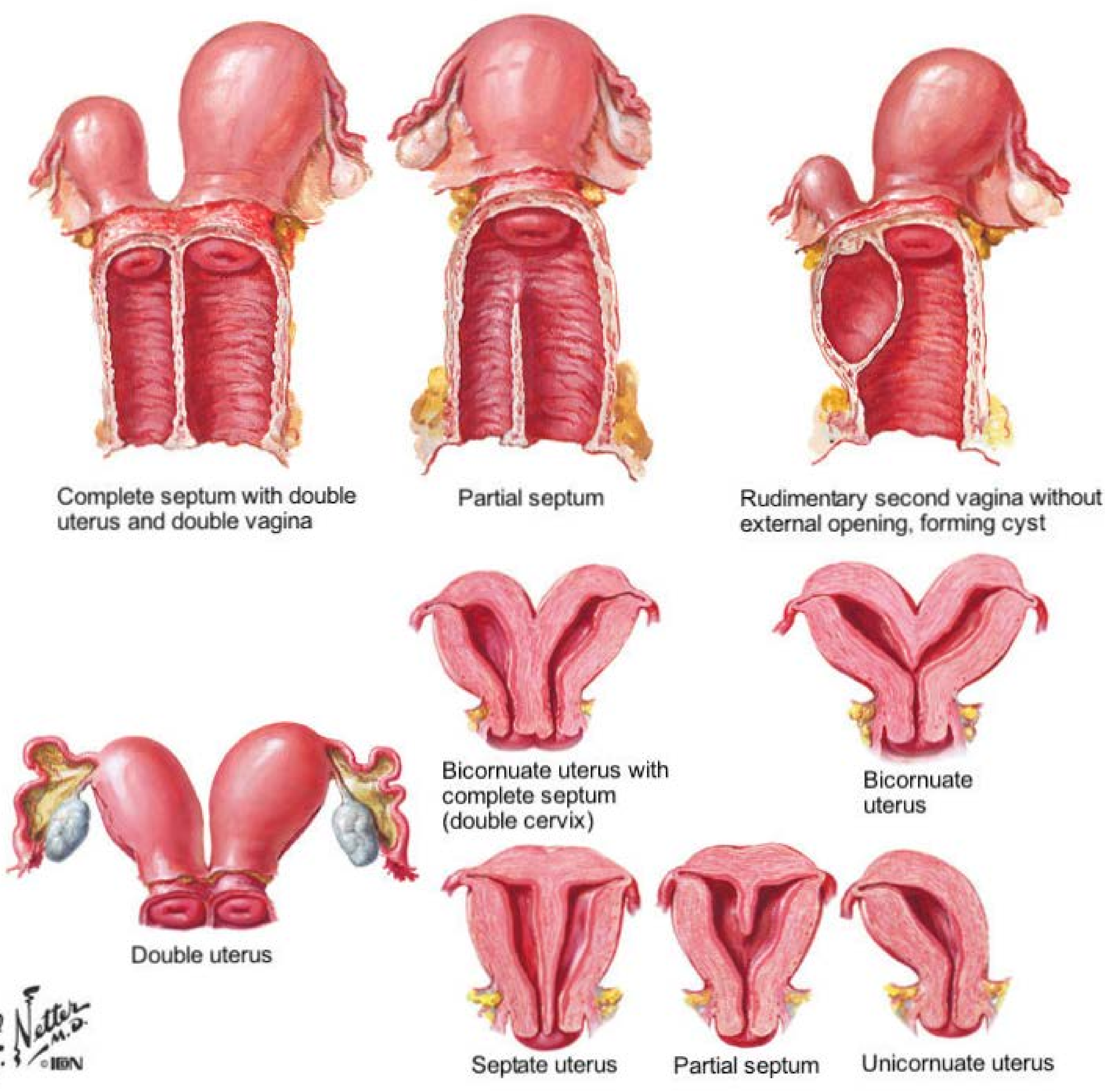
Anterior View of the Derivatives



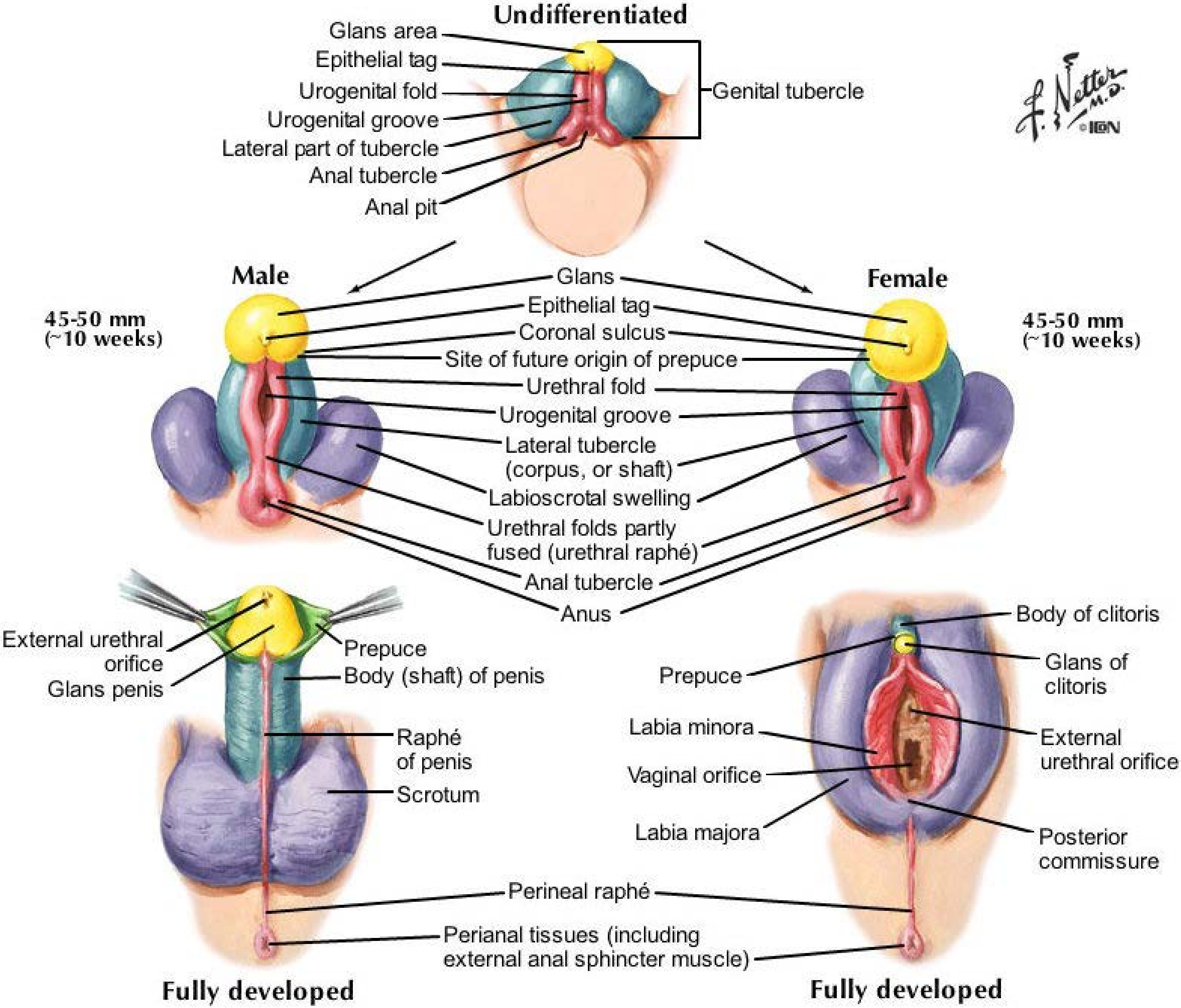
Anterior View of the Derivatives



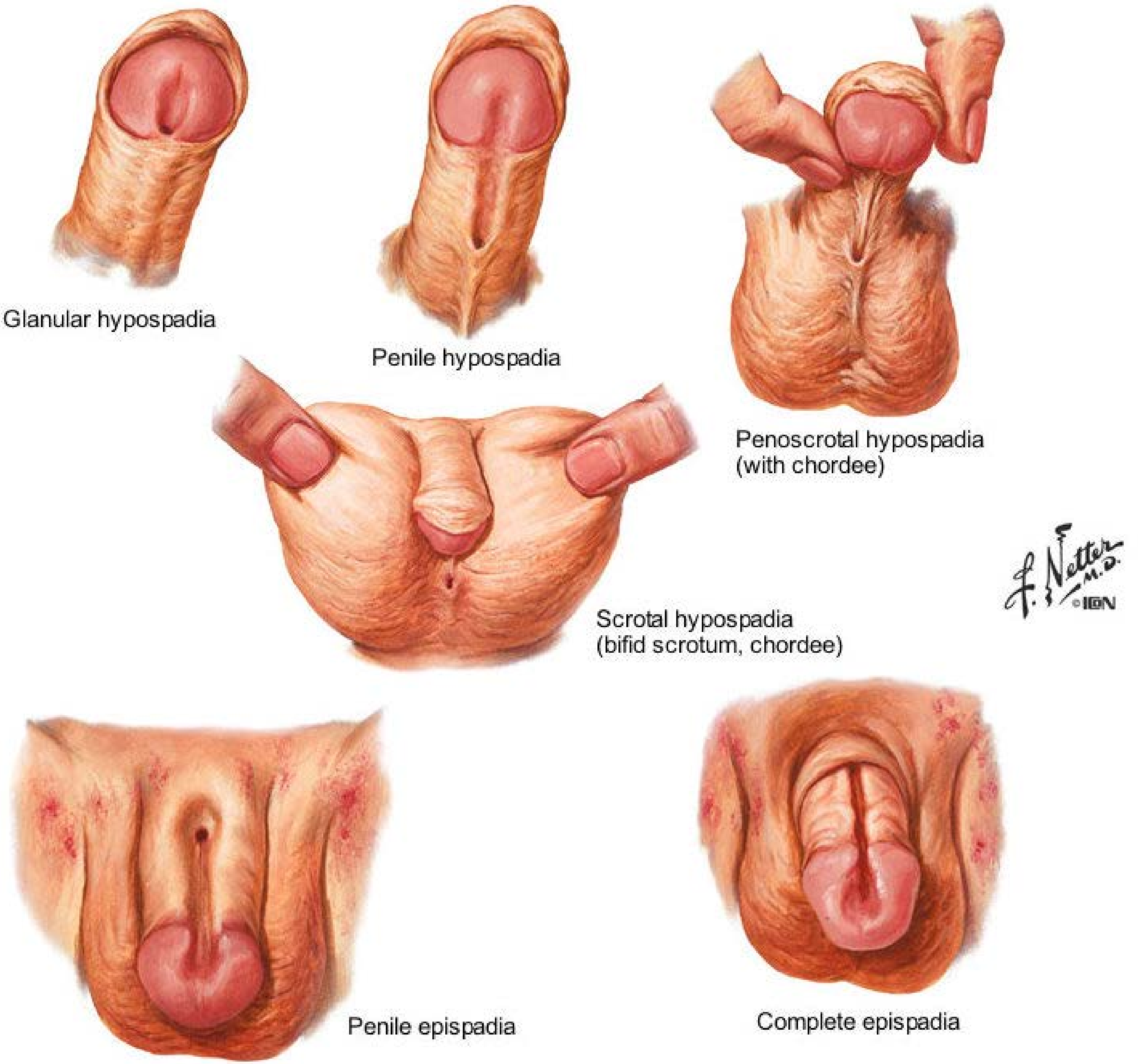
Paramesonephric Duct Anomalies



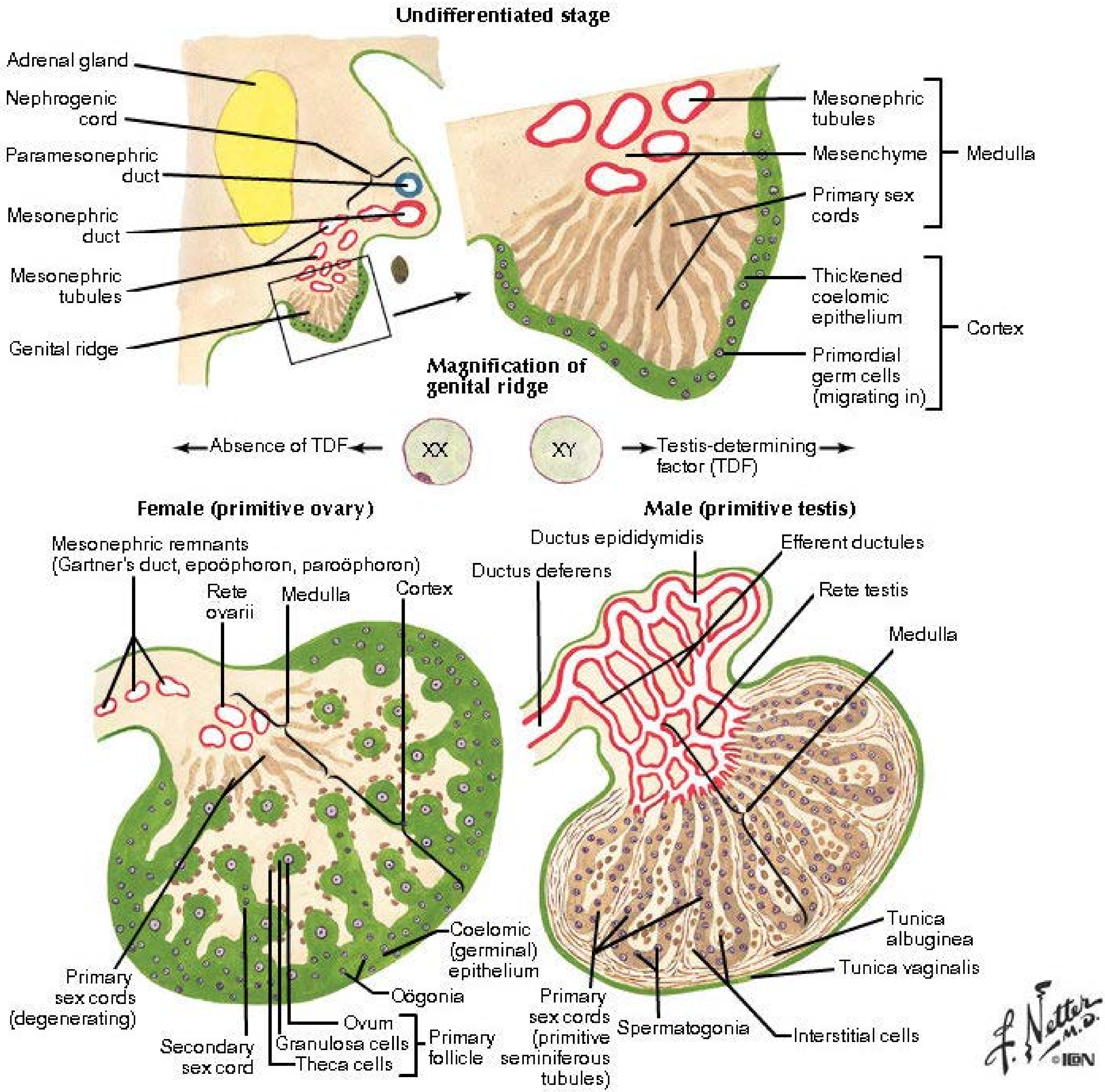
Homologues of the External Genital Organs



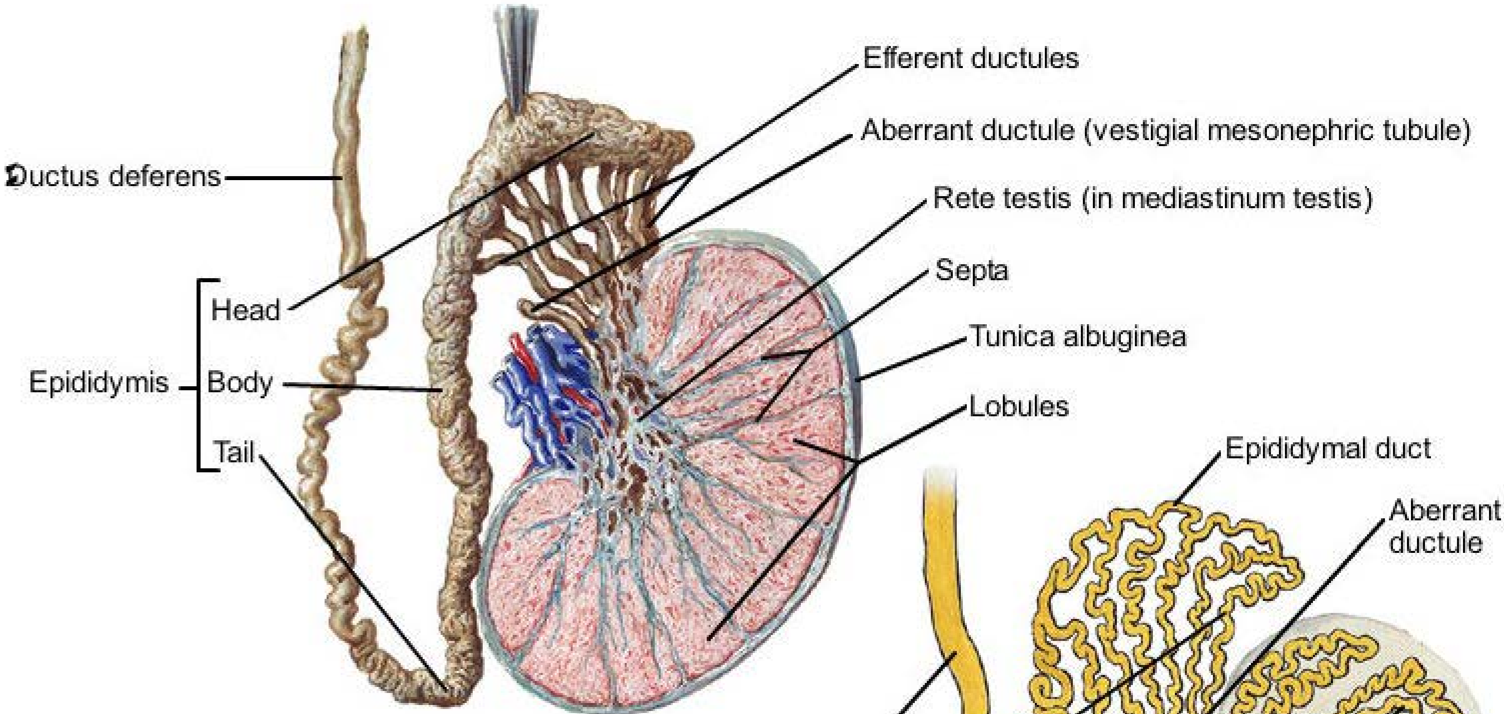
Hypospadia and Epispadias



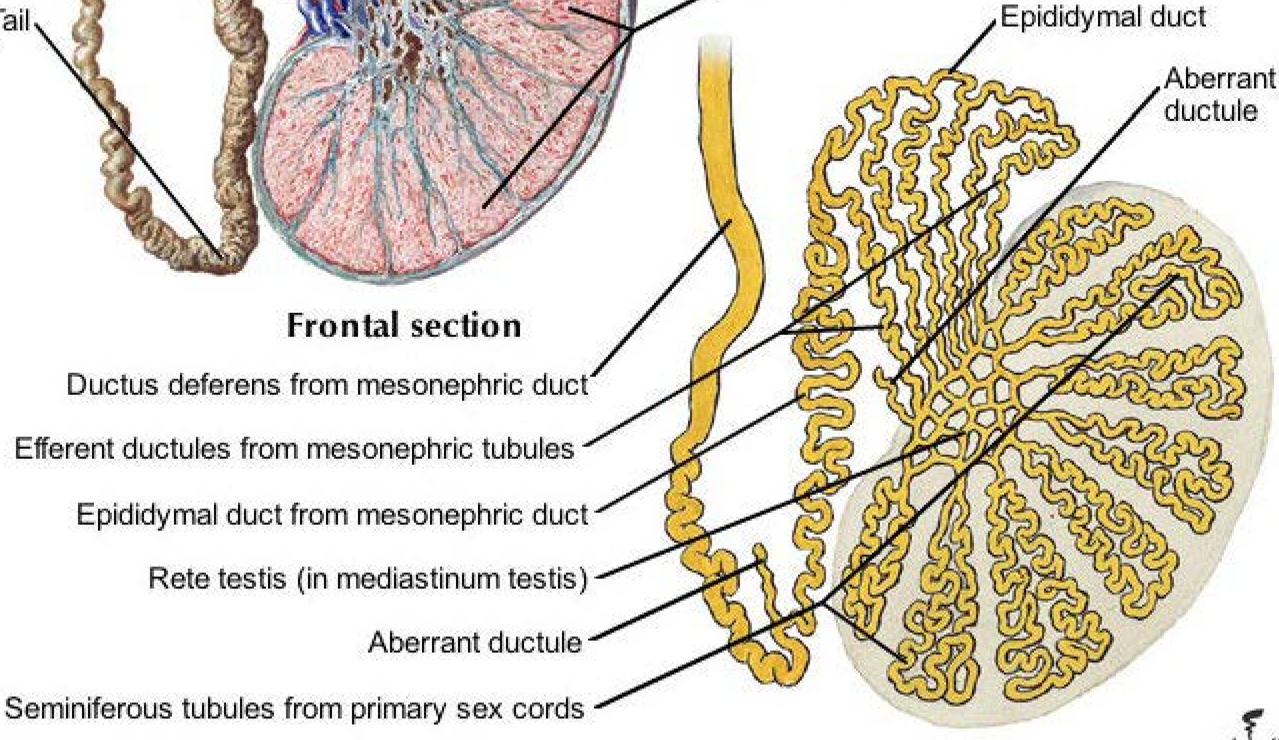
Gonadal Differentiation



Testis, Epididymis, and Ductus Deferens

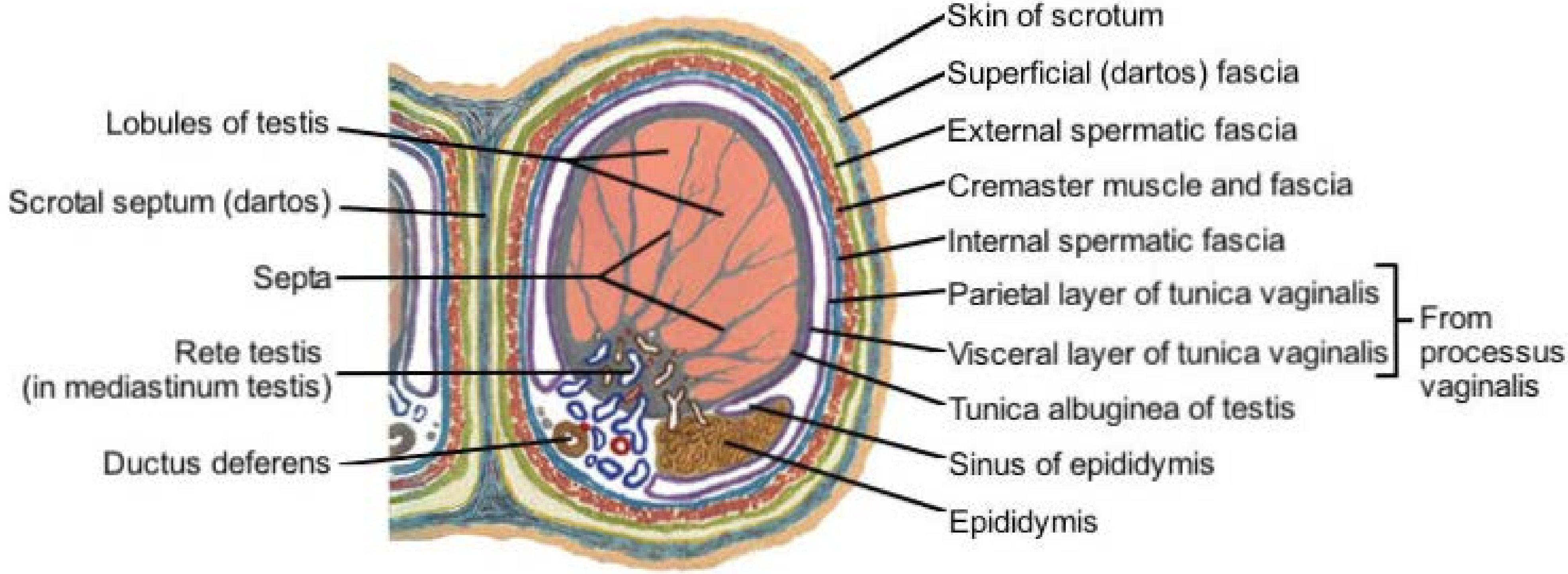


Frontal section



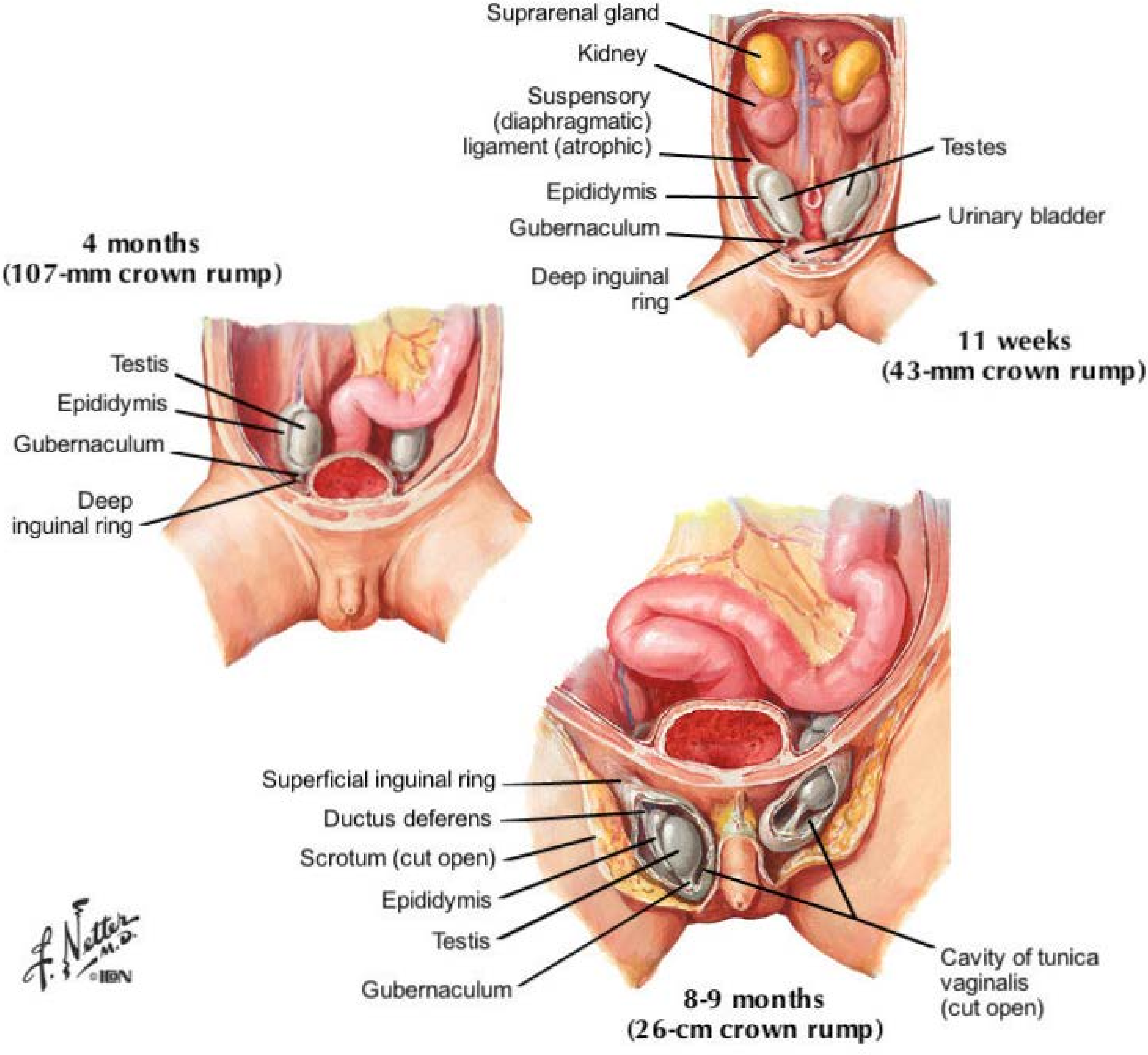
Schema

Testis, Epididymis, and Ductus Deferens

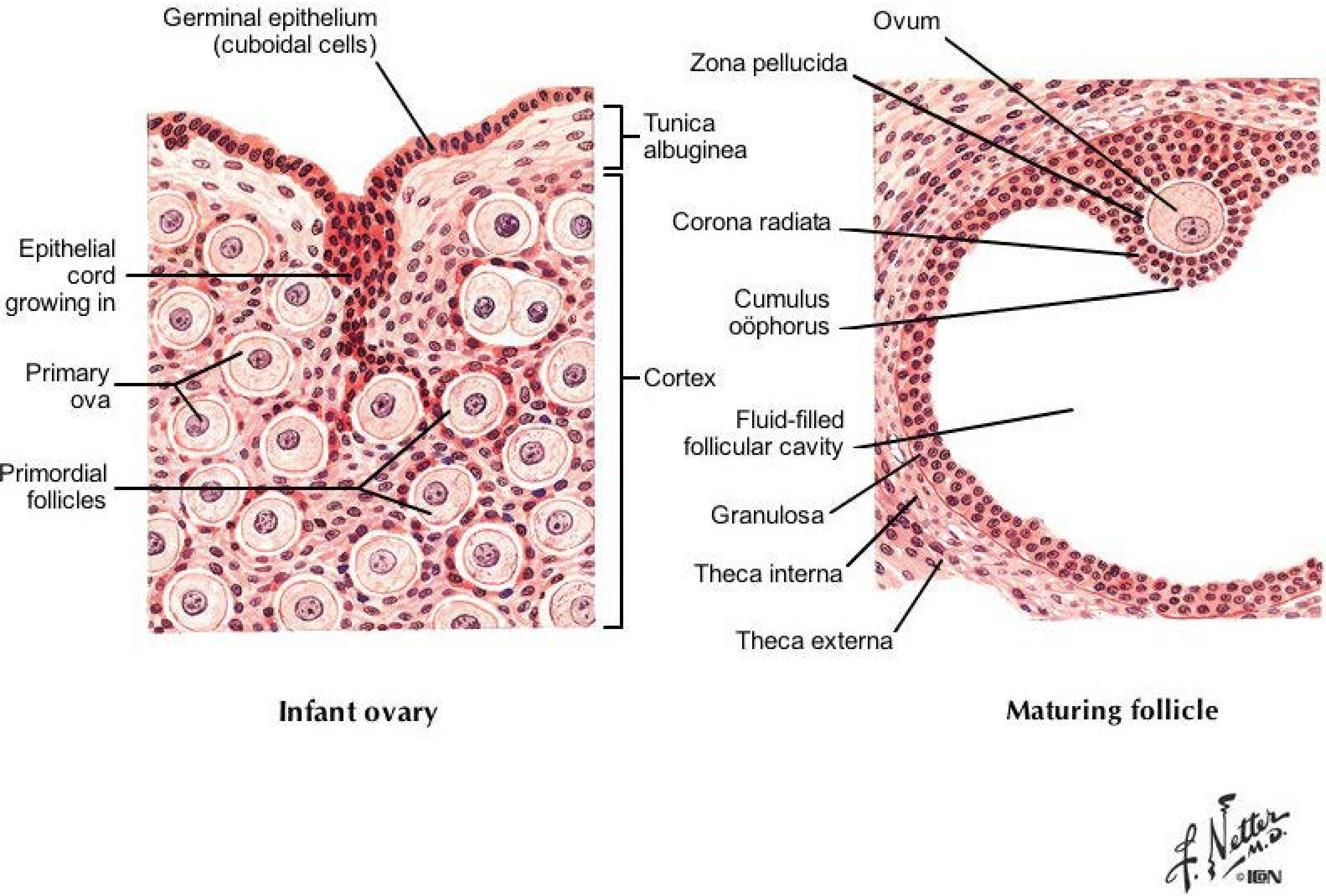


Cross section through scrotum and testis

Descent of Testis



Ova and Follicles

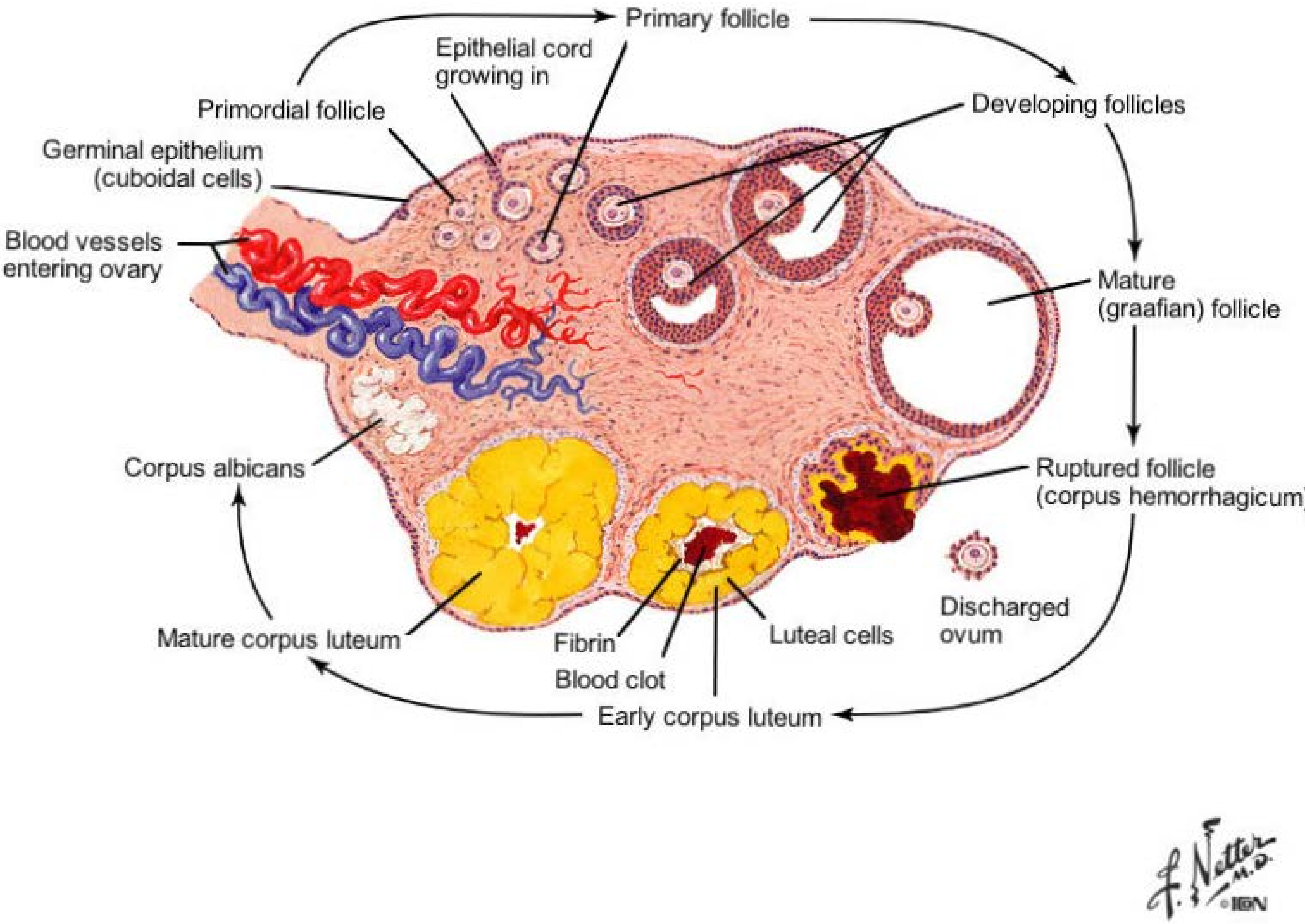


Infant ovary

Maturing follicle

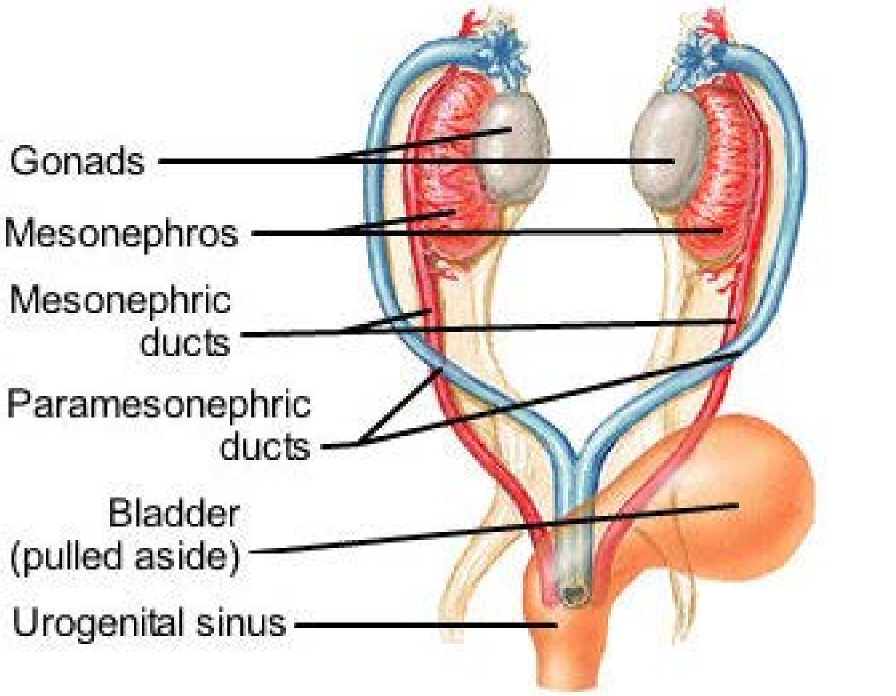
Ova and Follicles

Stages of ovum and follicle

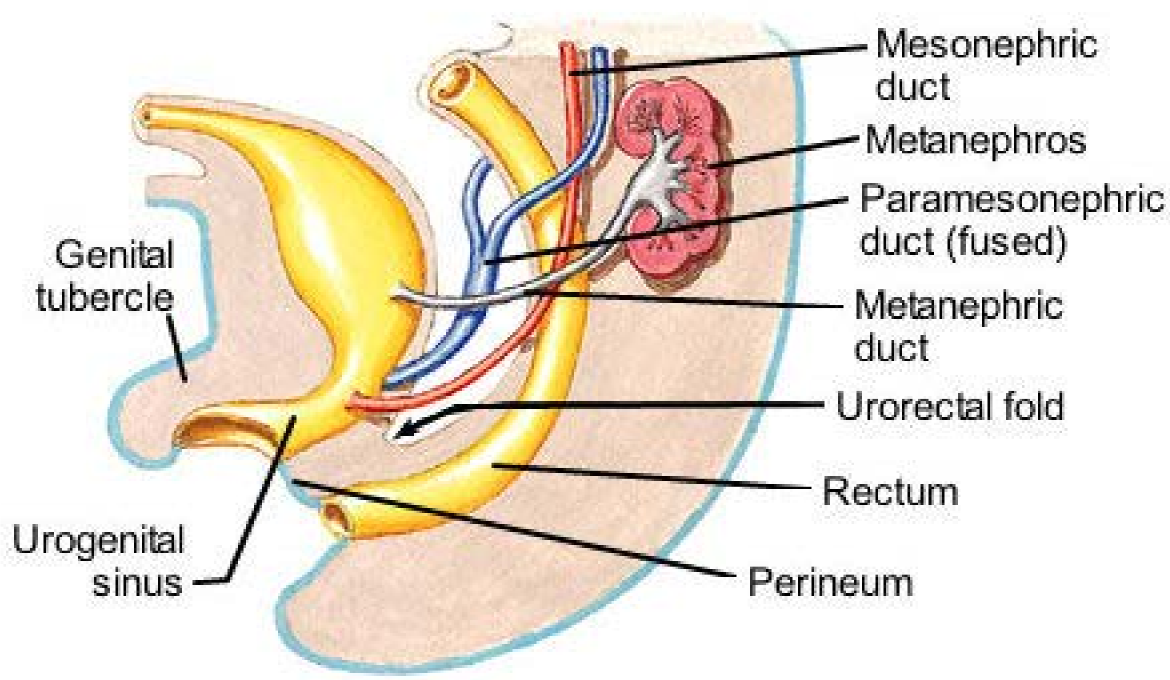


Summary of Urogenital Primordia and Derivatives

Undifferentiated

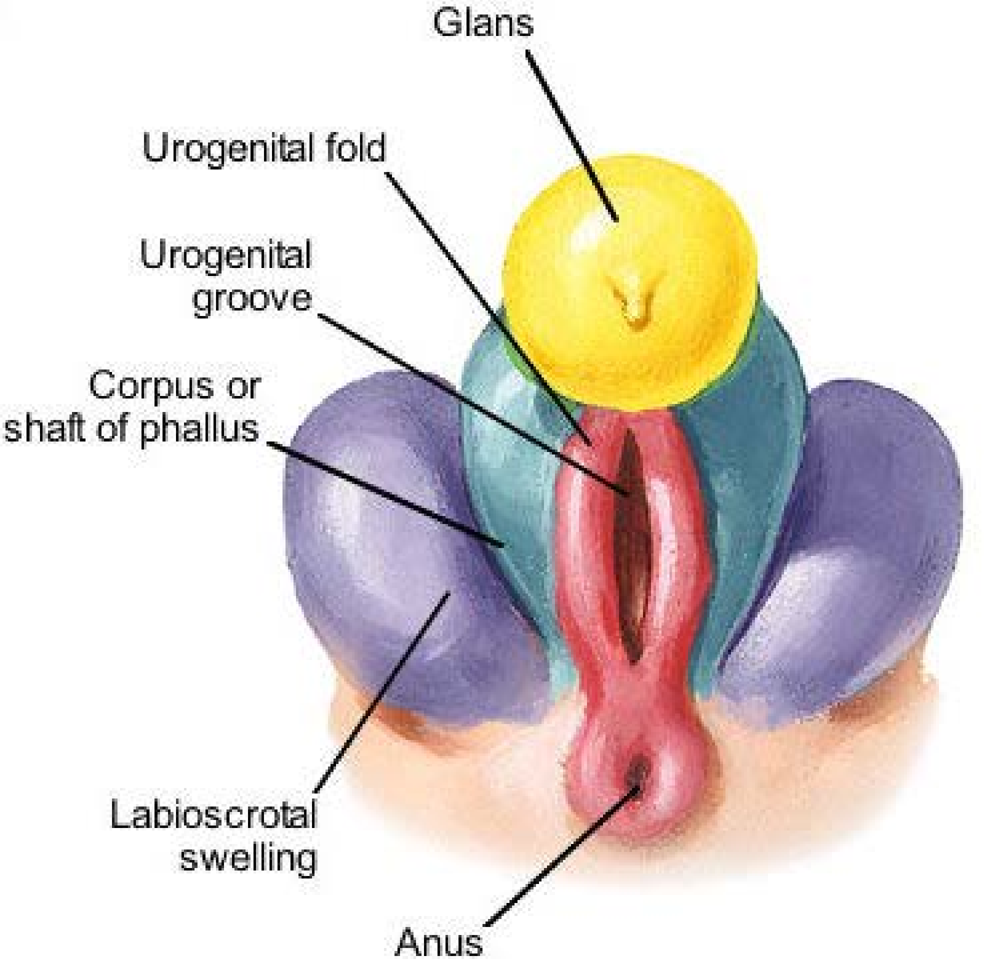


8-week indifferent stage, anterior view

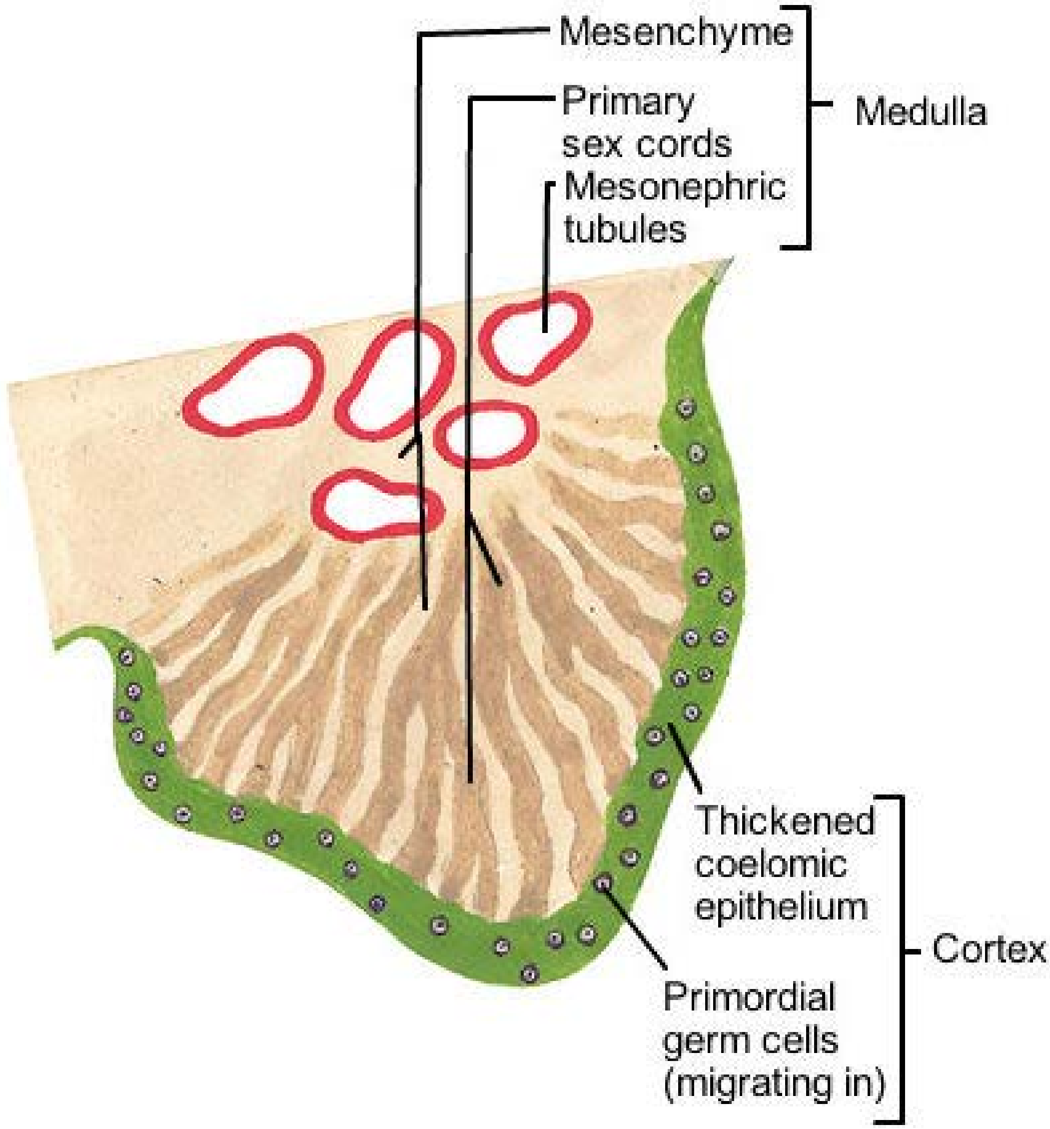


8-week indifferent stage, lateral view (gonad not shown)

Summary of Genital Primordia and Derivatives



10-week external genitalia primordia



Indifferent gonad developing from genital ridge

Urogenital Primordia and Derivatives

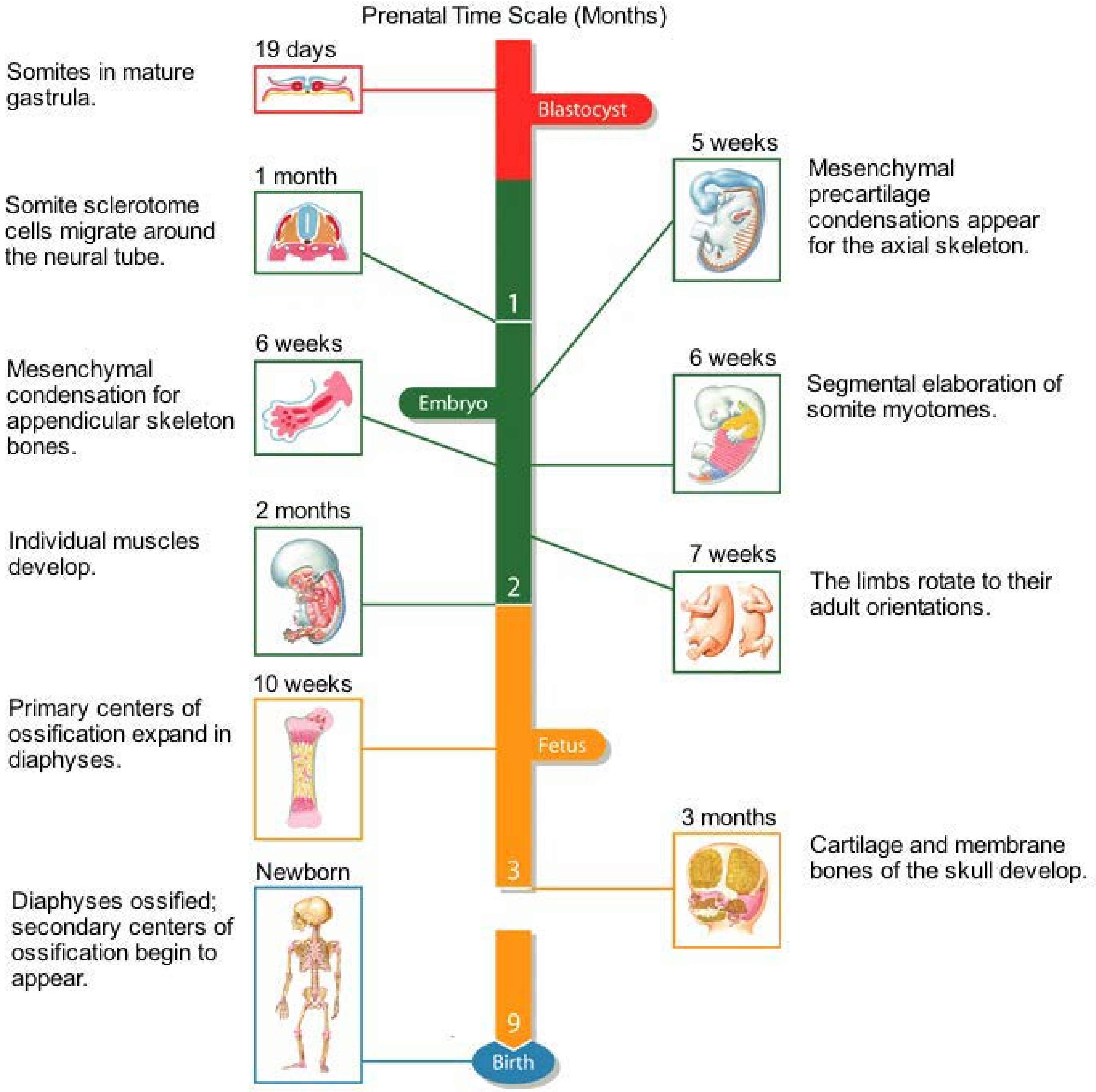
Female	Male
From the Urogenital Sinus	
Urinary bladder Urethra Lower vagina (and vaginal epithelium) Vestibule Greater vestibular/urethral glands	Urinary bladder Urethra (except navicular fossa) Prostate gland Bulbourethral glands Vestigial: prostatic utricle
From the Mesonephric Duct and Tubules	
Ureteric bud from mesonephric duct forms: Ureter Renal pelvis Major and minor calices Collecting tubules	Efferent ductules Duct of epididymis Ductus deferens Ejaculatory duct Seminal vesicles Ureter, renal pelvis, calices, and collecting tubules
Vestigial: epoophoron, paoophoron, appendix vesiculosa, Gartner's duct	Vestigial: appendix of testis
From the Paramesonephric Duct	
Uterine tubes, uterus, upper vagina Vestigial: hydatid	Vestigial: appendix of testis

Genital Primordia and Derivatives

GENITAL PRIMORDIA AND DERIVATIVES

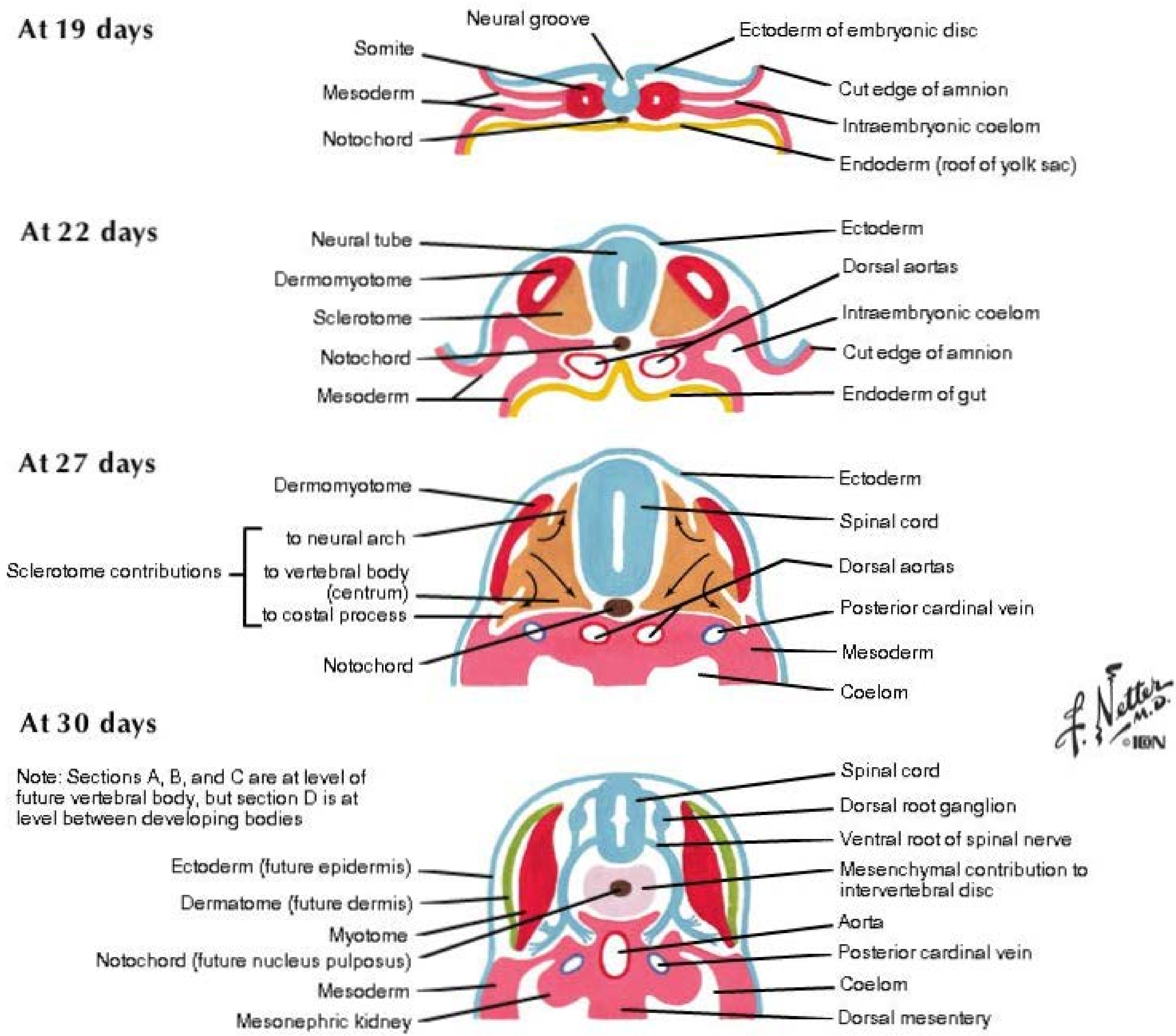
Female	Male
From the Genital Tubercle/Phallus	
Clitoris: Glans clitoridis Corpora cavernosa clitoridis Bulb of the vestibule	Penis: Glans penis (and navicular fossa) Corpora cavernosum penis Corpus spongiosum penis
From the Urogenital Folds	
Labia minora Perineal raphé Perianal tissue (and external anal sphincter)	Ventral aspect of penis Most of the penile urethra Perineal raphé Perianal tissue (and external sphincter)
From the Labioscrotal Folds	
Labia majora	Scrotum
From the Indifferent Gonad	
Ovary: follicles from secondary sex cords in cortex Vestigial: rete ovarii in medulla	Testis: seminiferous tubules from primary sex cords Rete testis in medulla
From the Gubernaculum	
Ovarian ligament Round ligament of the uterus	Gubernaculum testis

THE MUSCULOSKELETAL SYSTEM
TIMELINE



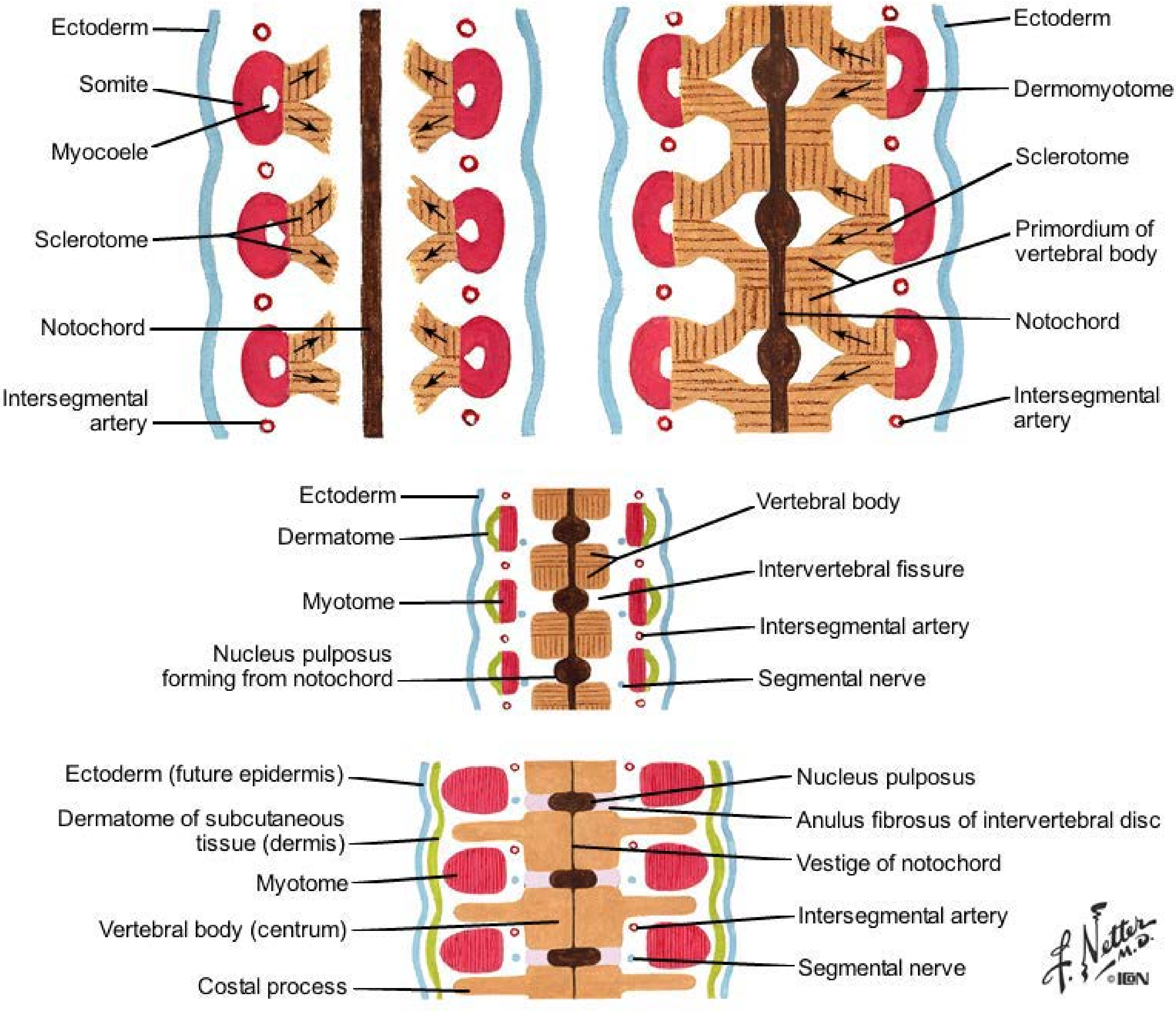
Muscular System: Primordia

Differentiation of somites into myotomes, sclerotomes, and dermatomes
Cross section of human embryos



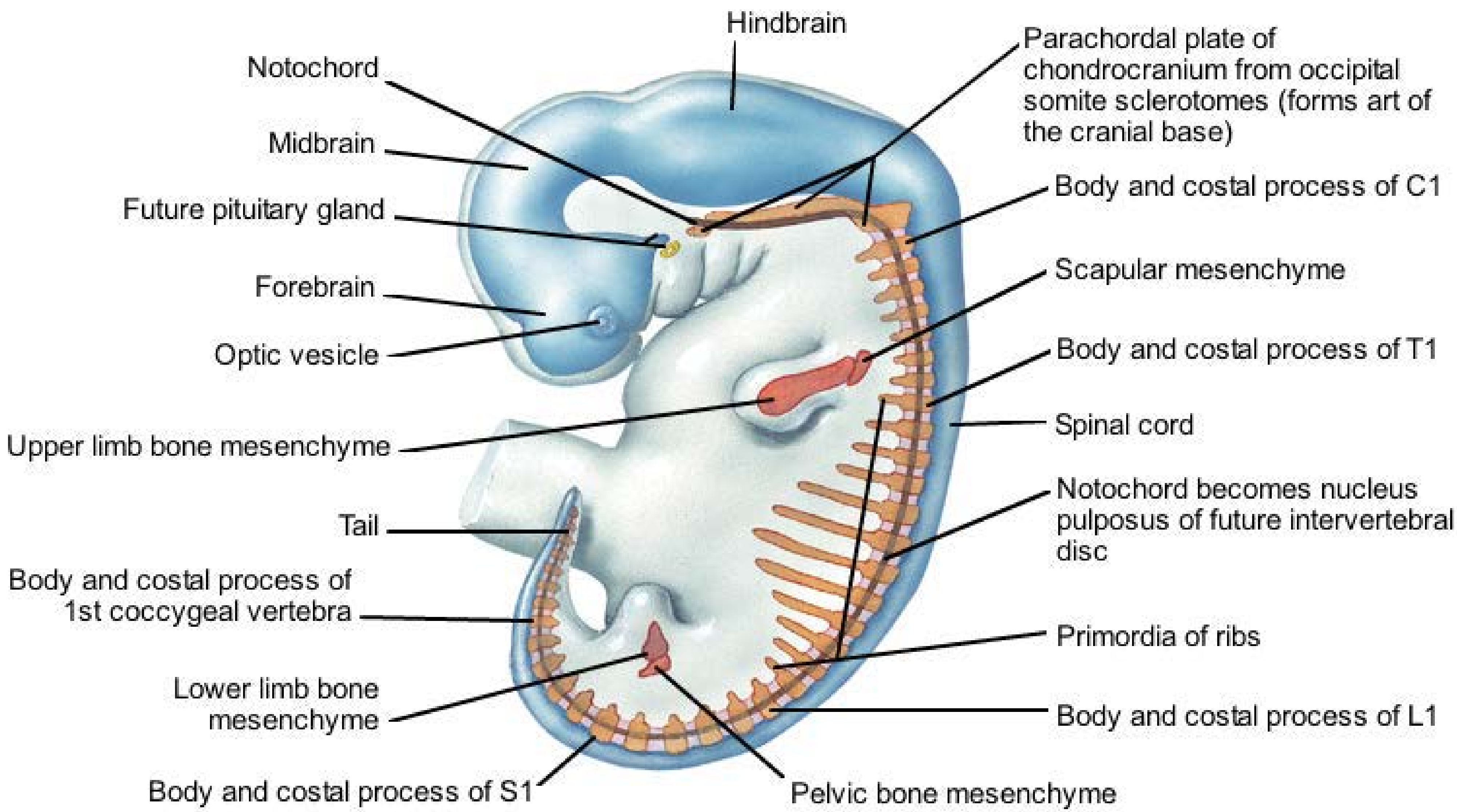
Muscle and Vertebral Column Segmentation

Progressive stages in formation of vertebral column, dermatomes, and myotomes

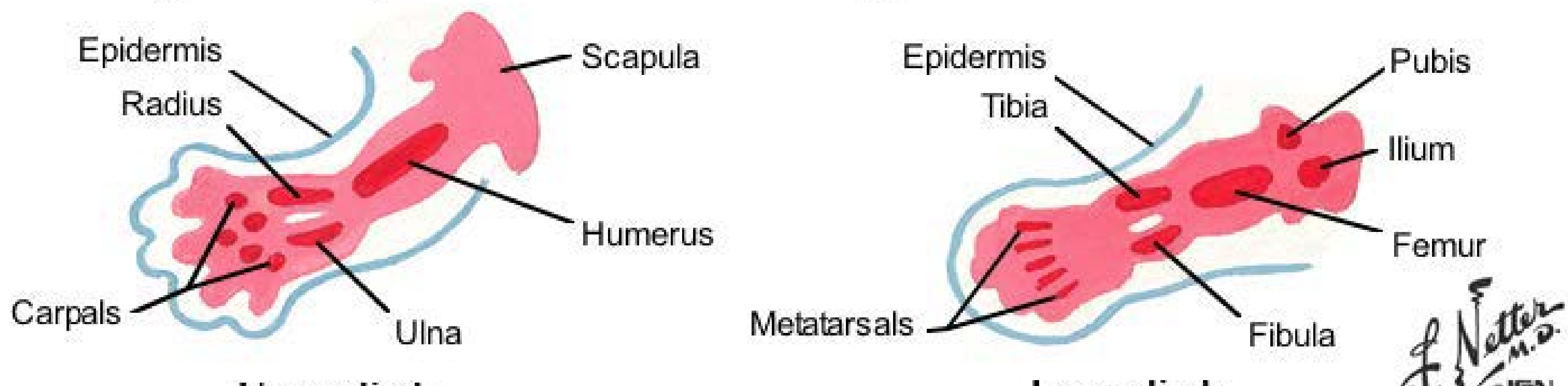


Mesenchymal Primordia and 5 and 6 Weeks

Mesenchymal precartilage primordia of axial and appendicular skeletons at 5 weeks



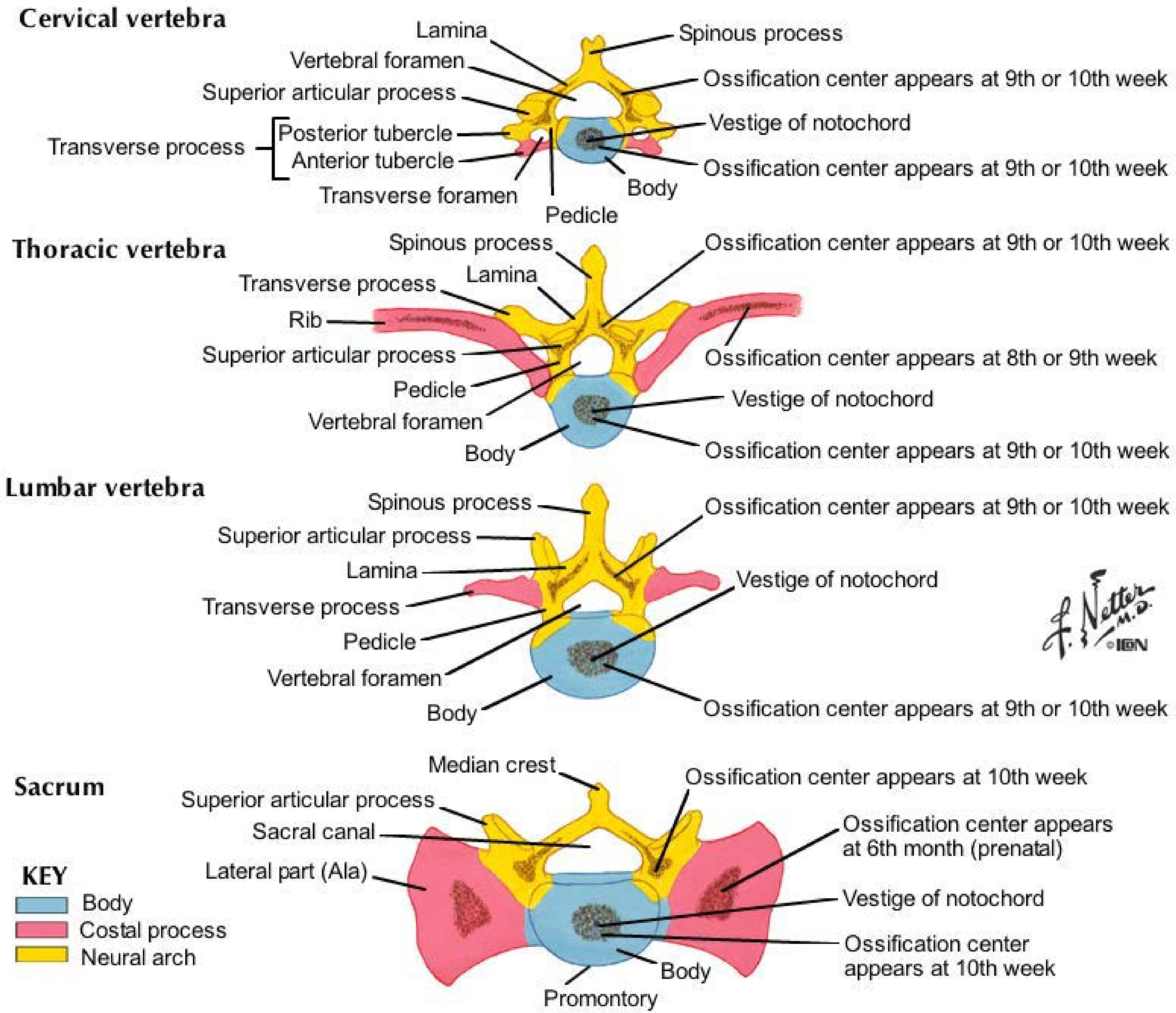
Precartilage mesenchymal cell condensations of appendicular skeleton at 6th week



Upper limb **Lower limb**

Ossification of the Vertebral Column

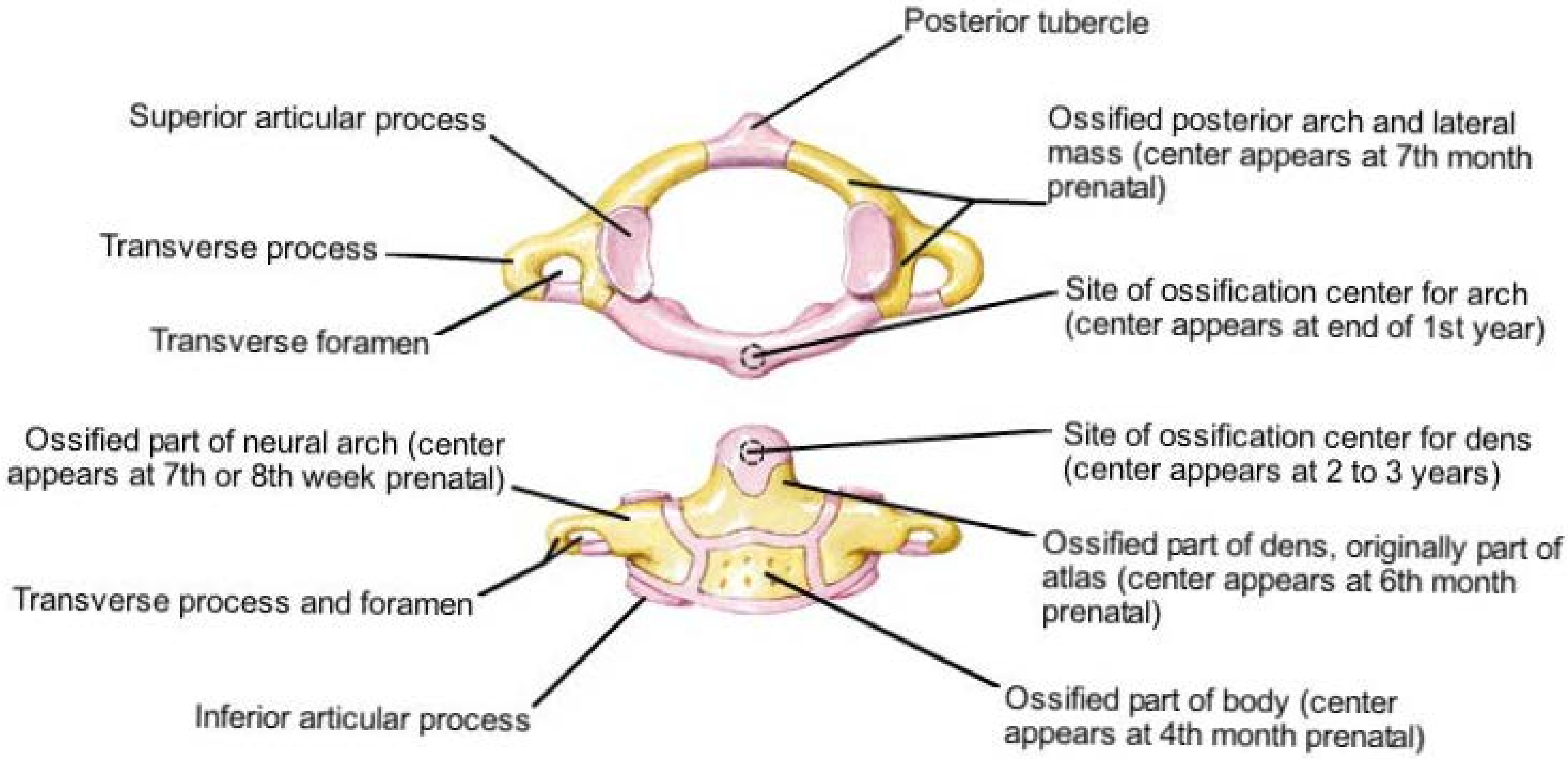
Fate of body, costal process, and neural arch components of vertebral column, with sites and time of appearance of ossification centers



Development of the Atlas, Axis, Ribs, and Sternum

First and second cervical vertebrae at birth

A. 1st cervical vertebra (atlas) (superior view)



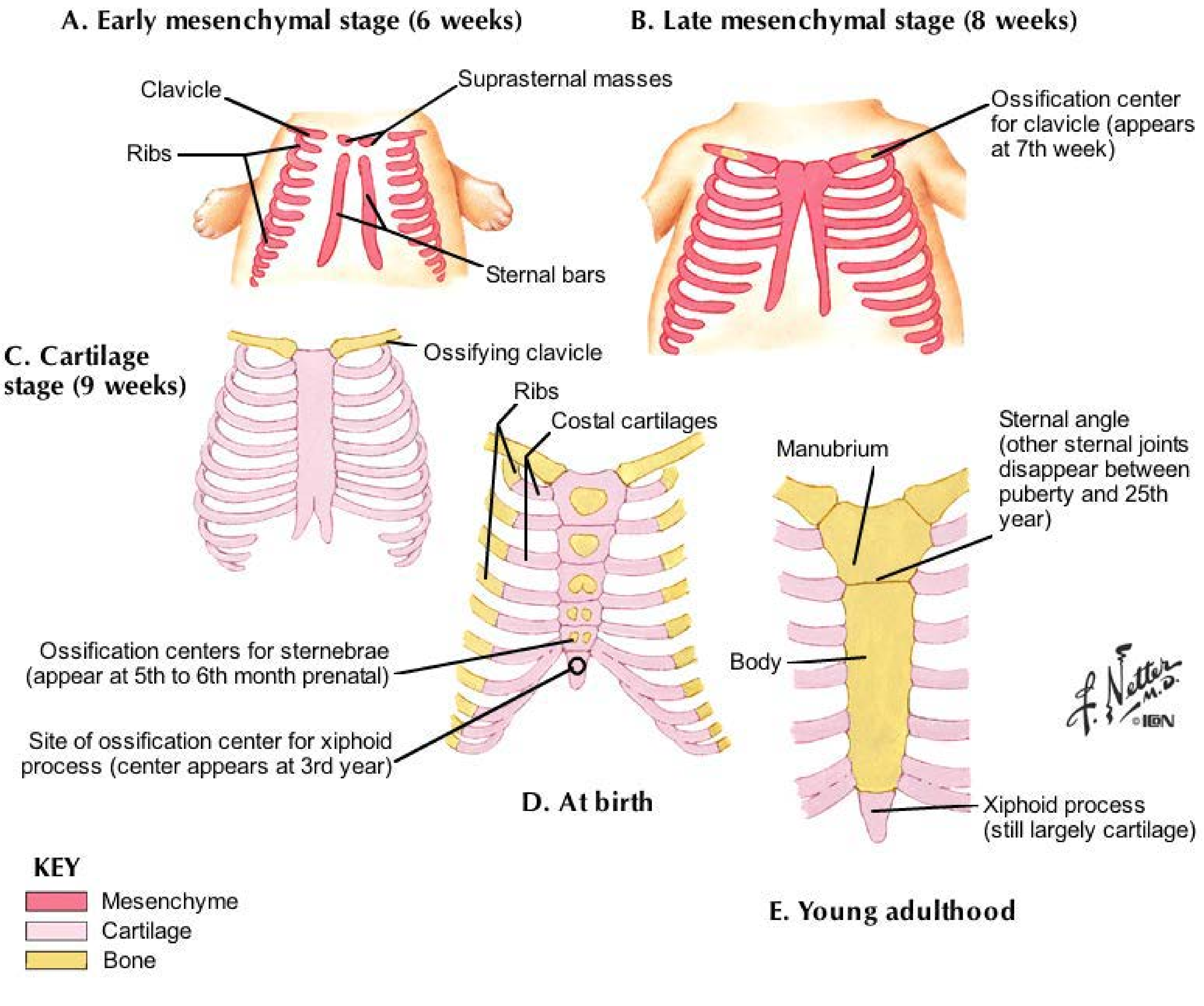
B. 2nd cervical vertebra (axis) (anterior view)

KEY

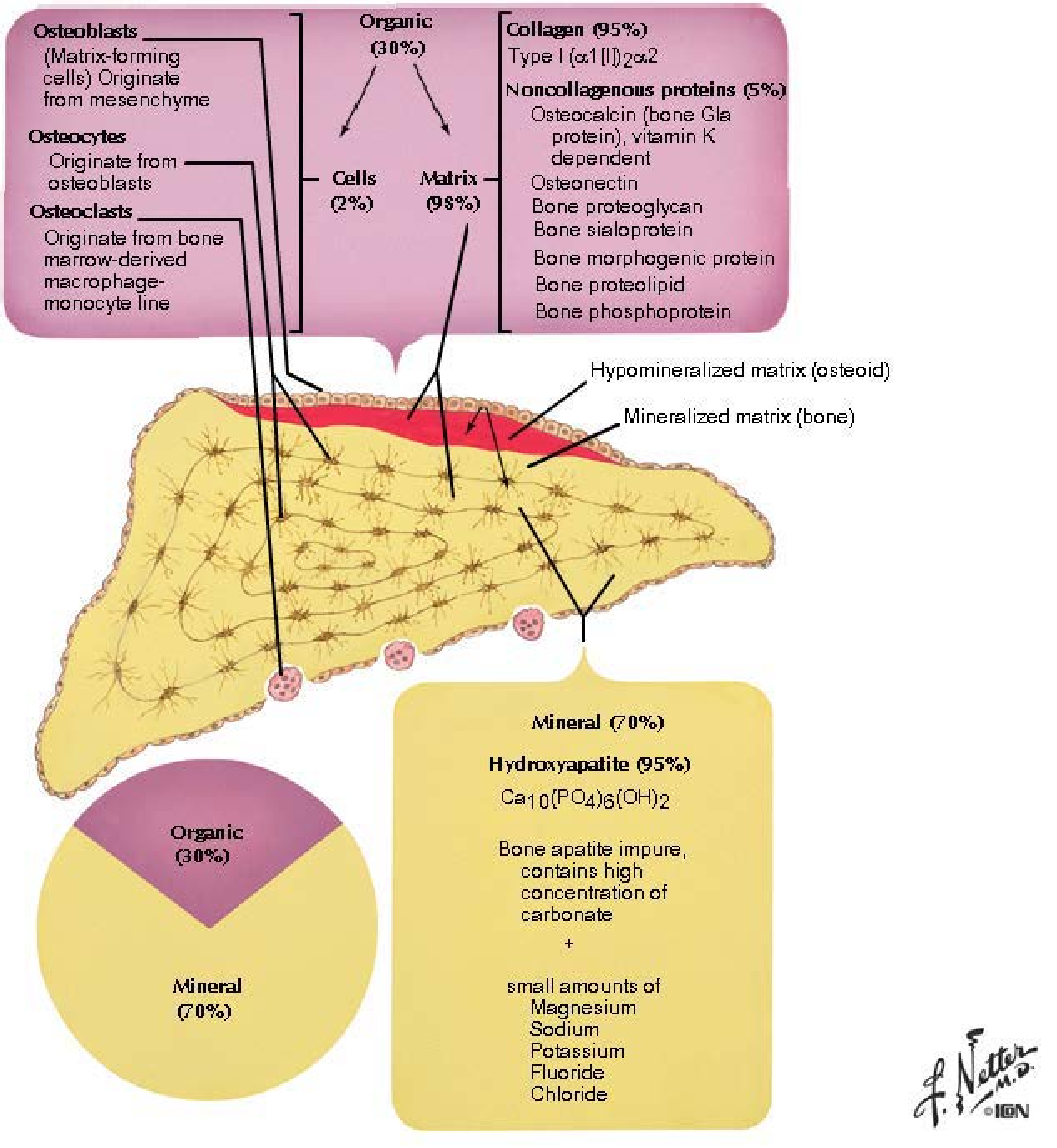
- Cartilage
- Bone

Development of the Atlas, Axis, Ribs, and Sternum

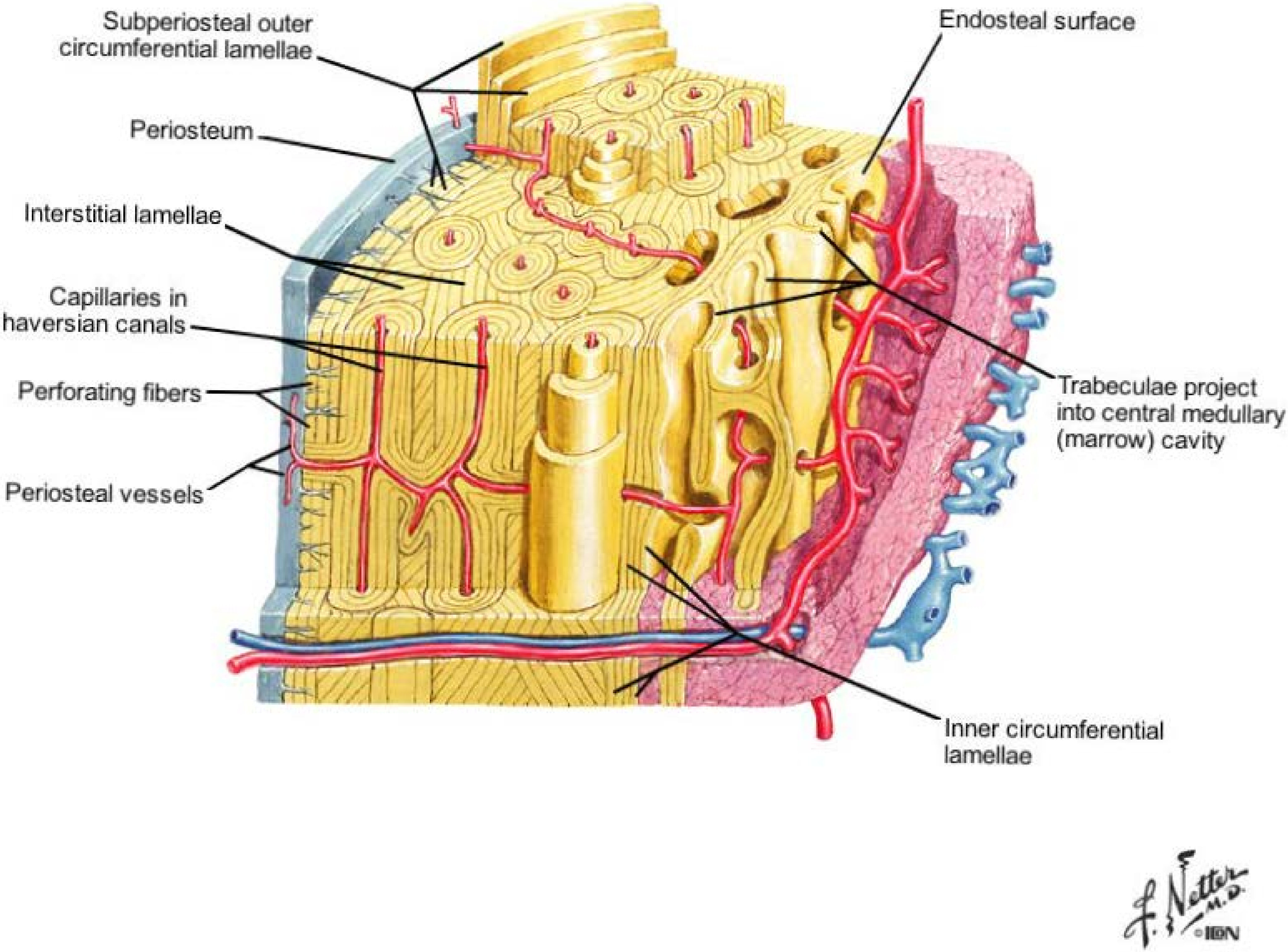
Development of sternum



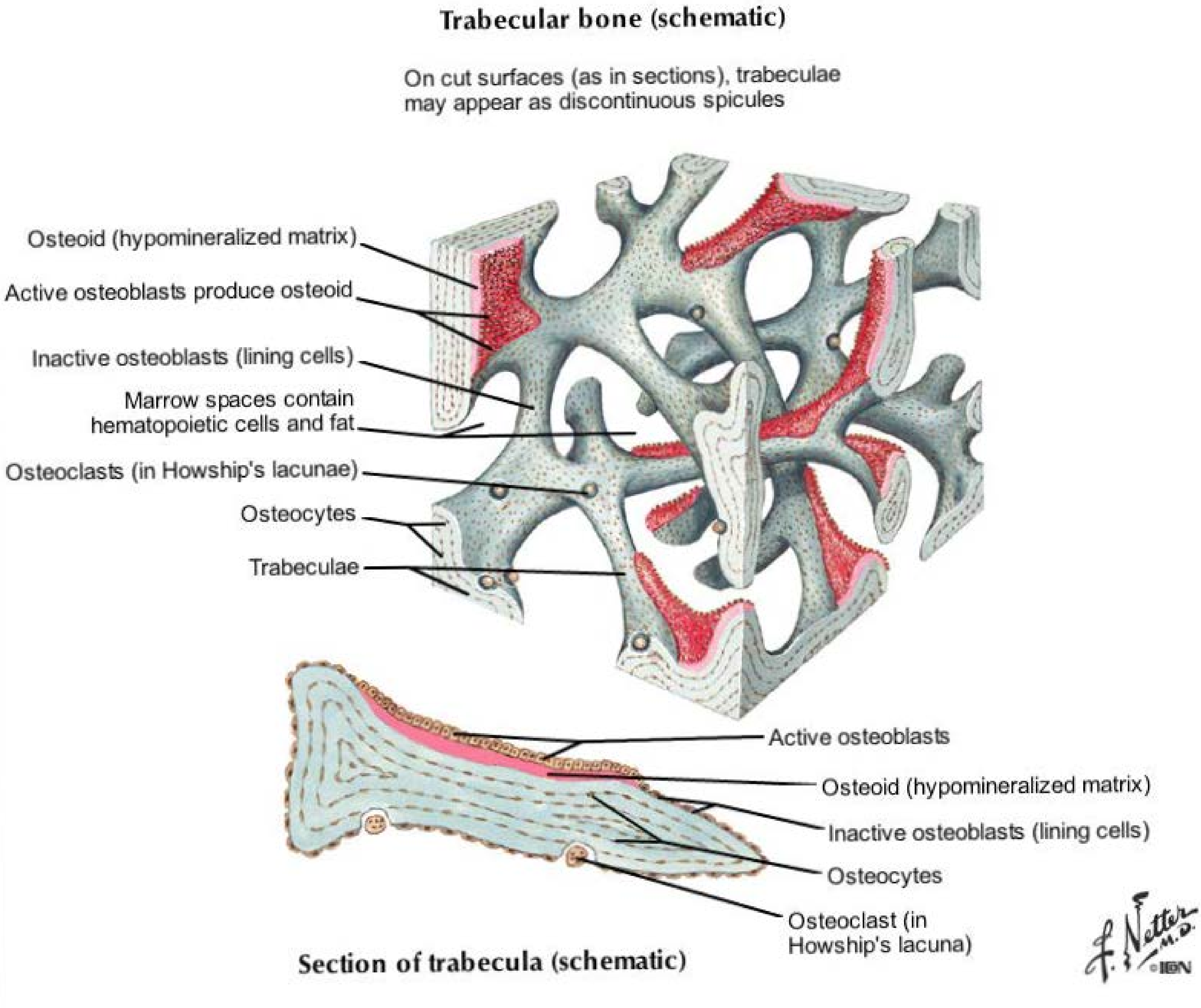
Bone Cells and Bone Deposition
Composition of bone



Histology of Bone
Cortical (compact) bone

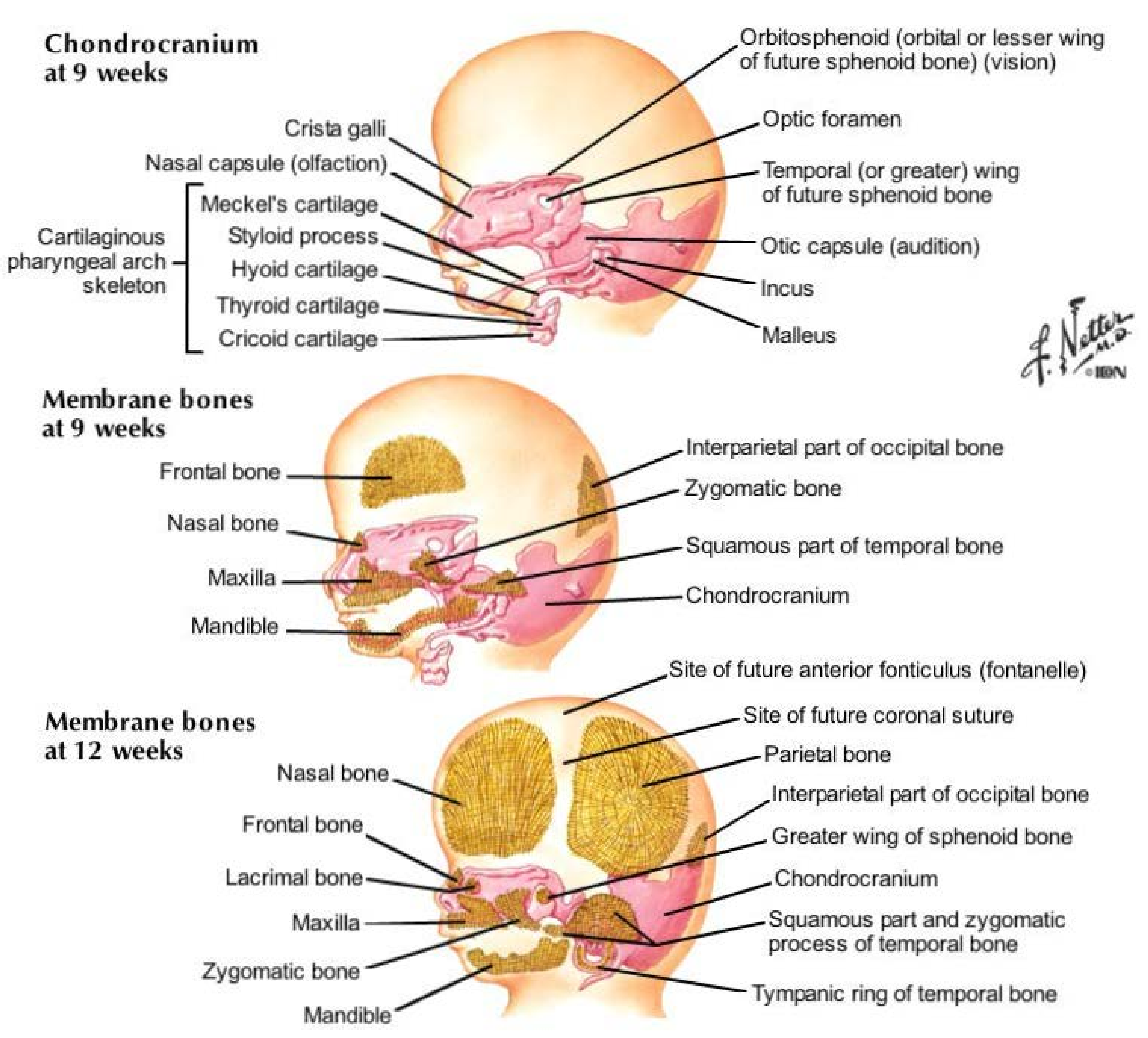


Histology of Bone



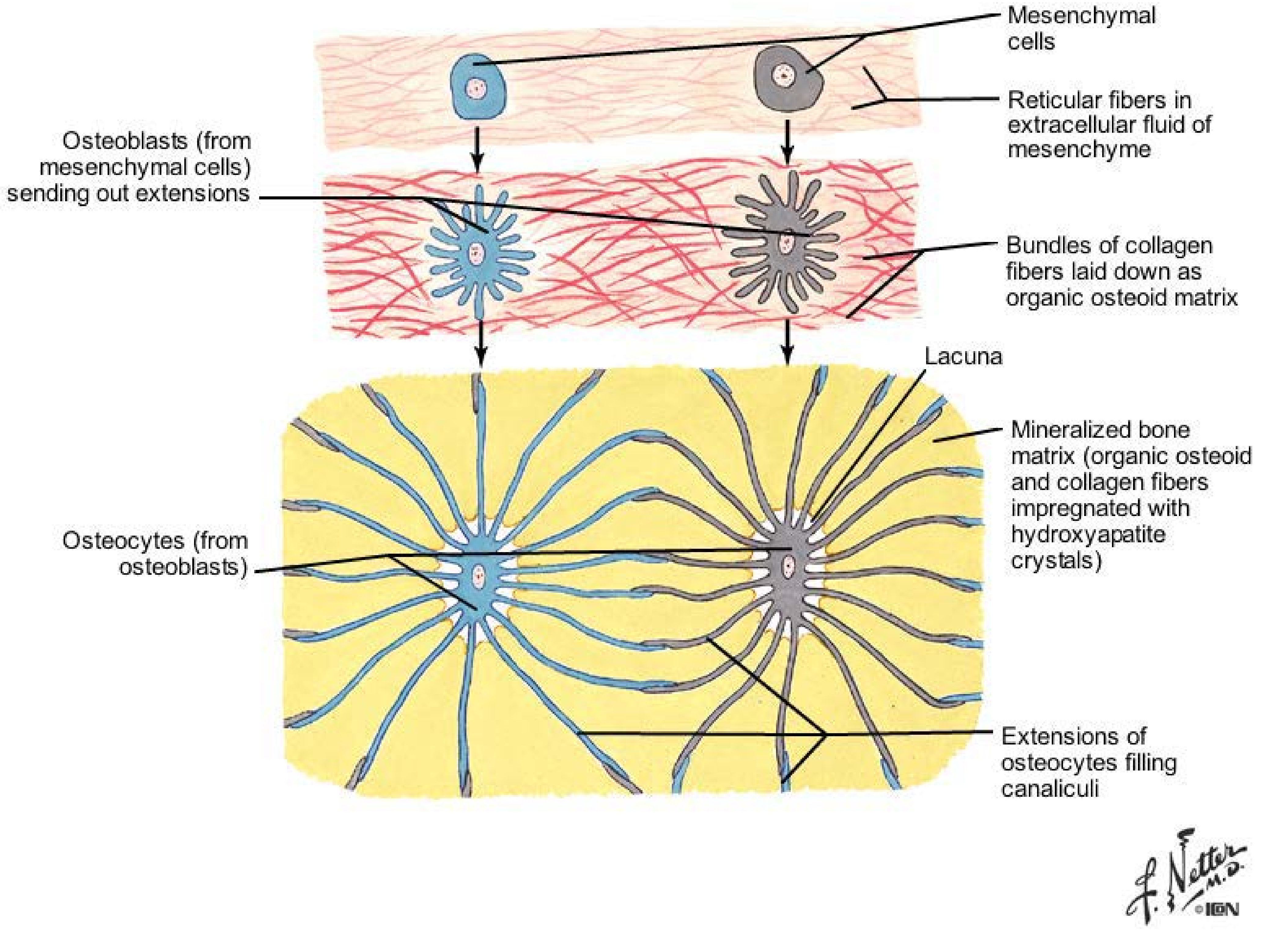
Membrane Bone and Skull Development

Early development of skull



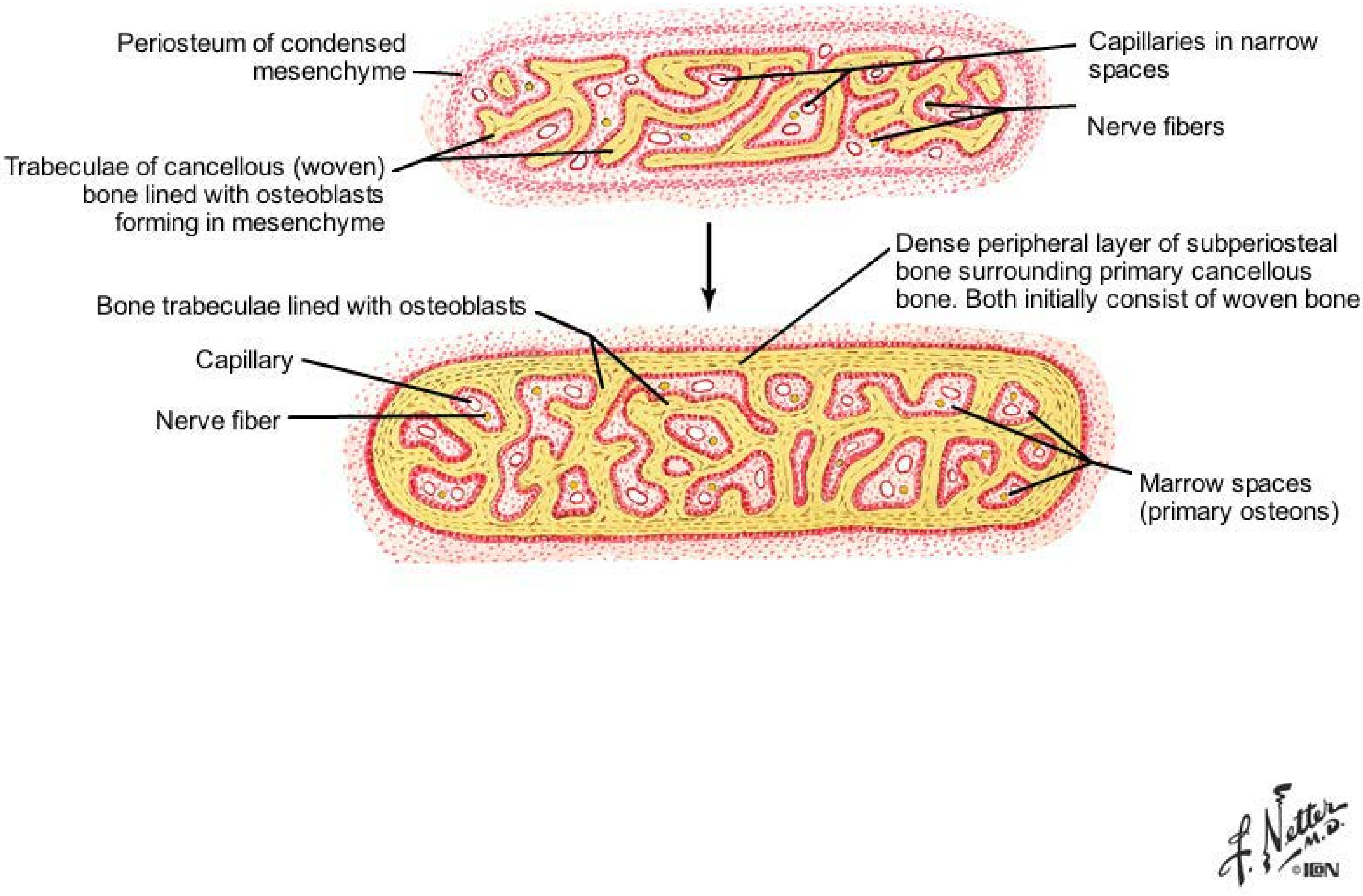
Bone Development in Mesenchyme

Initial bone formation in mesenchyme



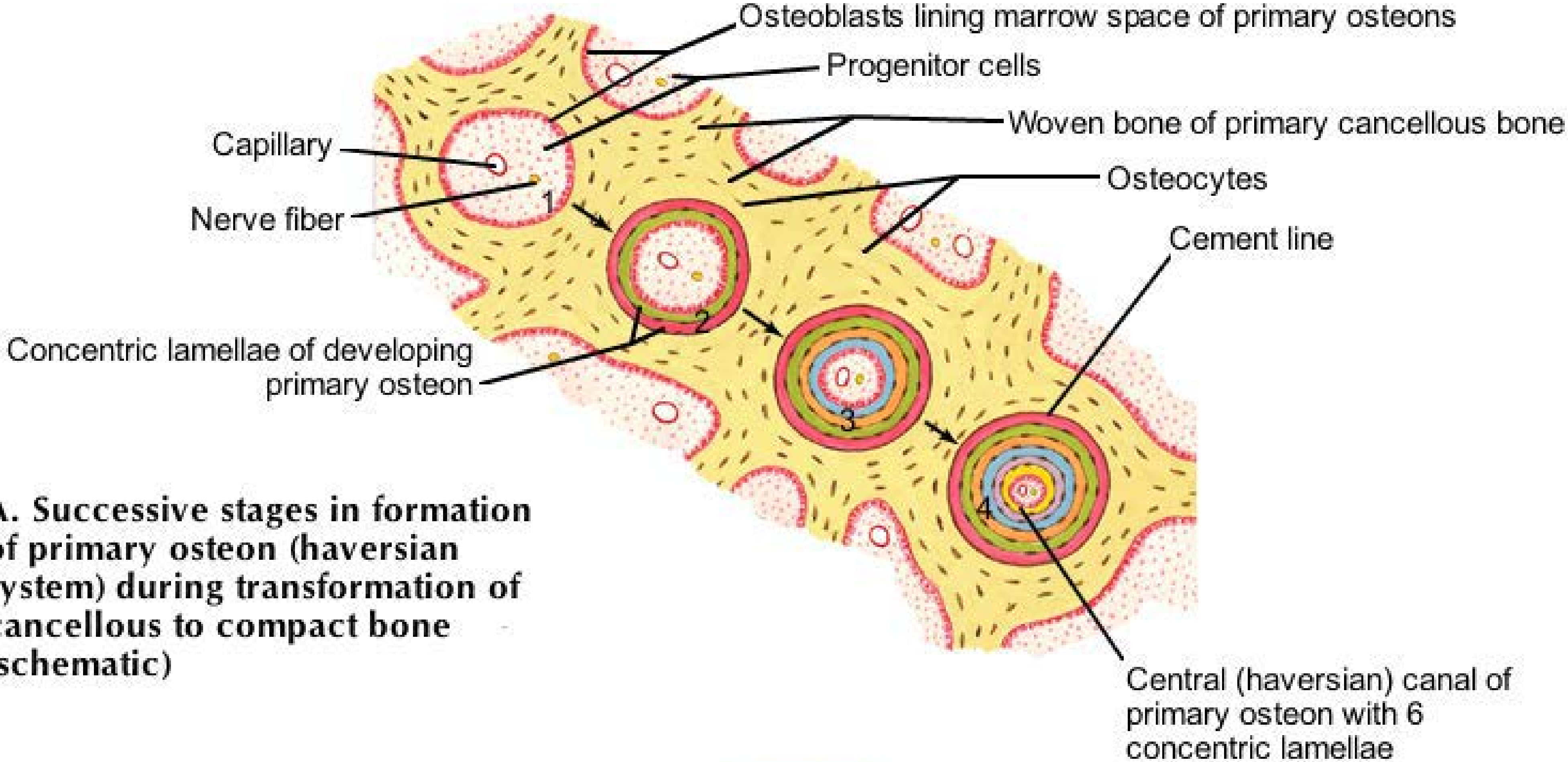
Bone Development in Mesenchyme

Early stages of flat (membrane or dermal) bone formation

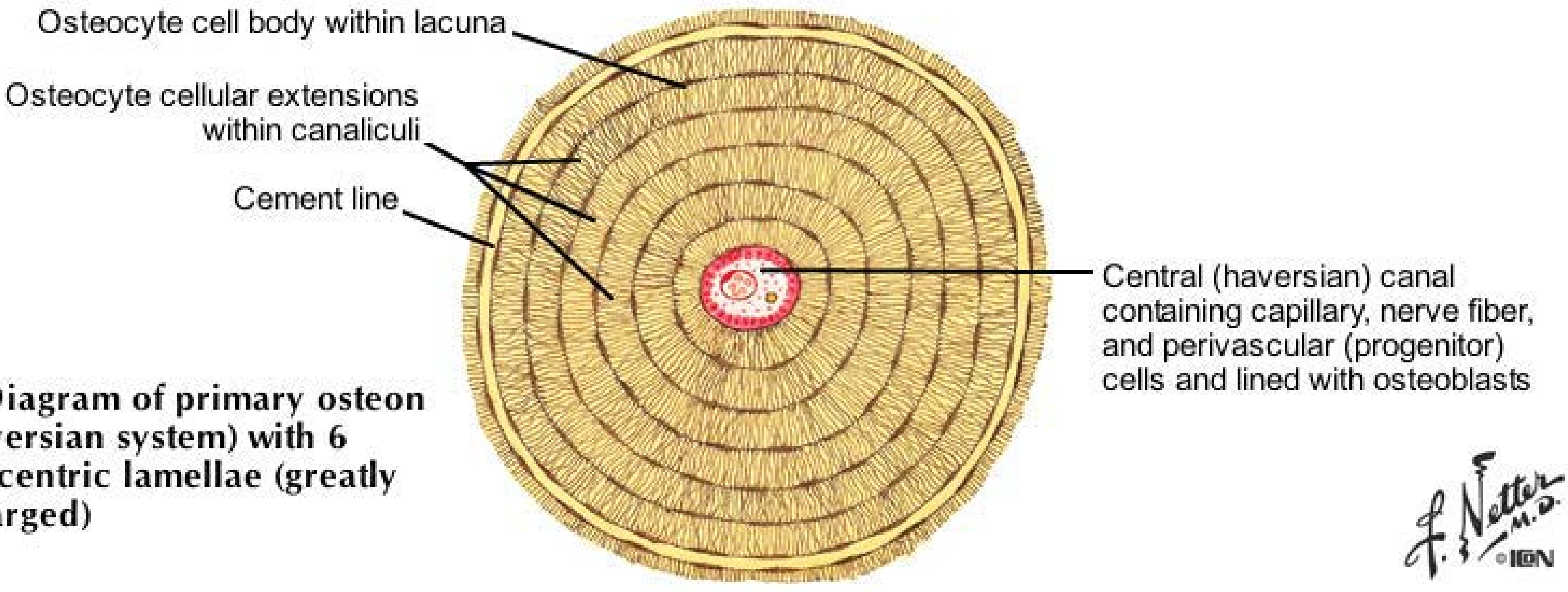


Osteon Formation

Primary osteon formation in mesenchymal bone development



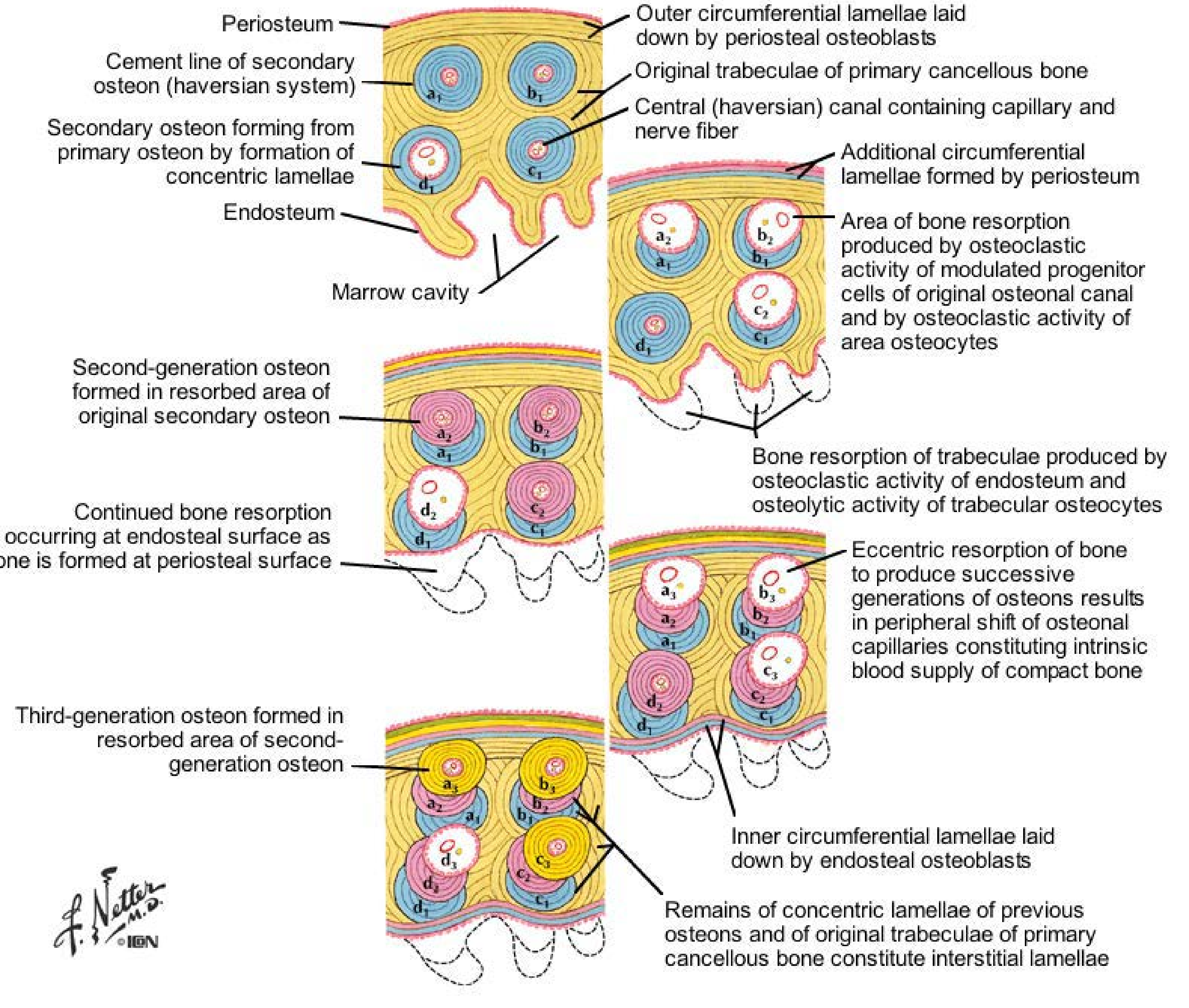
A. Successive stages in formation of primary osteon (haversian system) during transformation of cancellous to compact bone (schematic)



B. Diagram of primary osteon (haversian system) with 6 concentric lamellae (greatly enlarged)

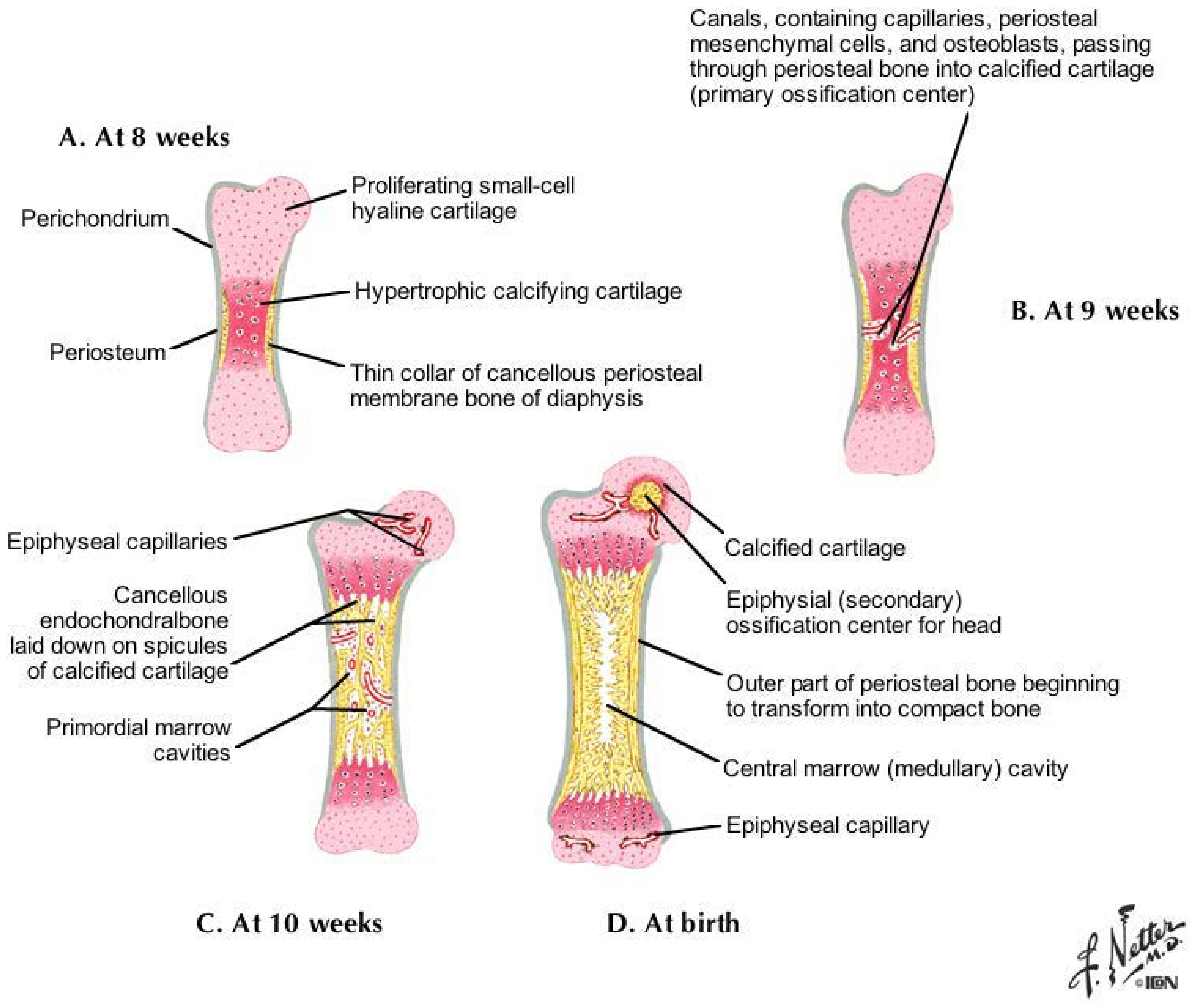
Compact Bone Development and Remodeling

Growth in width of a bone and osteon remodeling



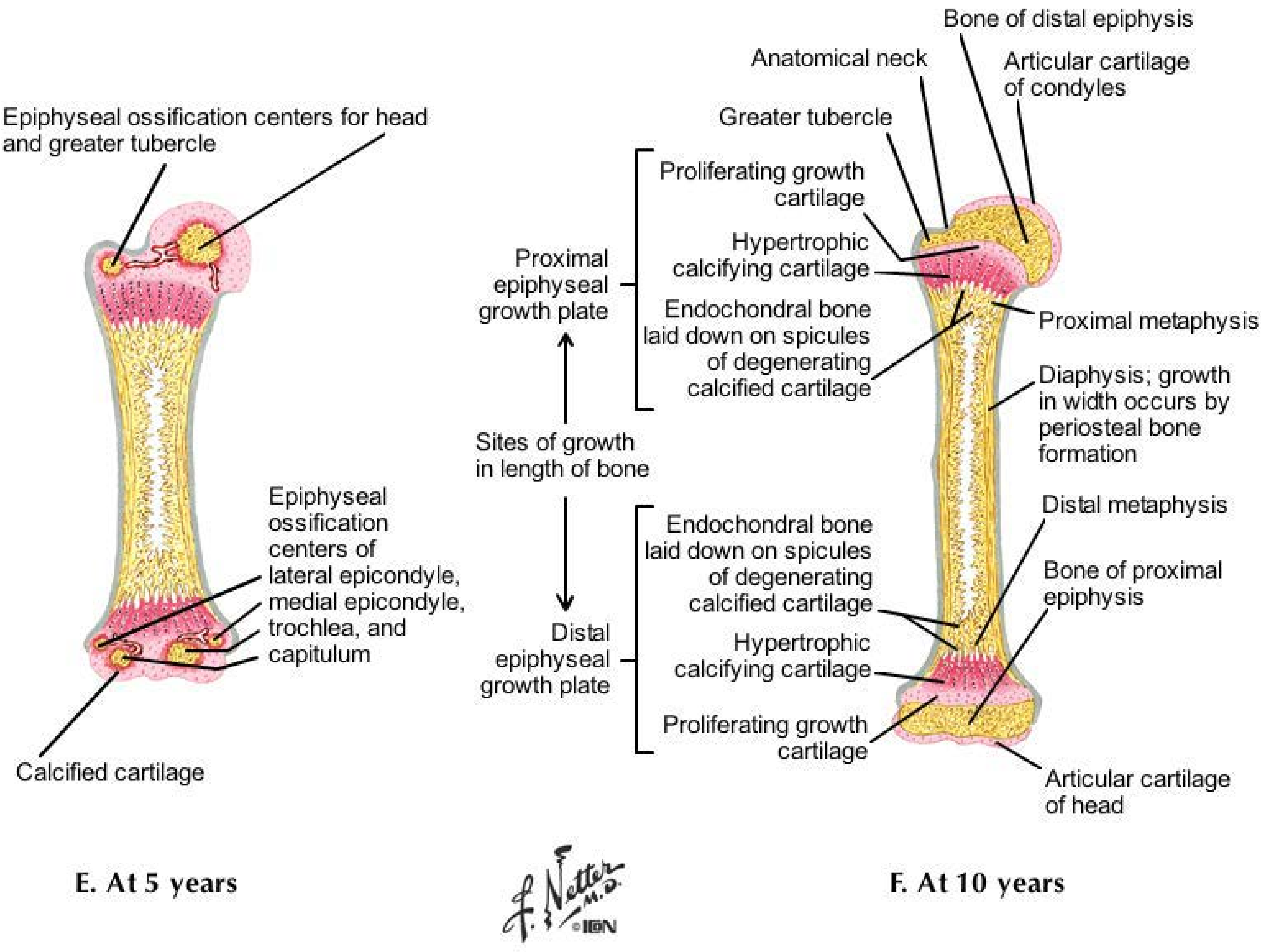
Endochondral Ossification in a Long Bone

Growth and ossification of long bones (humerus, midfrontal sections)



Endochondral Ossification in a Long Bone

Growth and ossification of long bones (humerus, midfrontal sections)

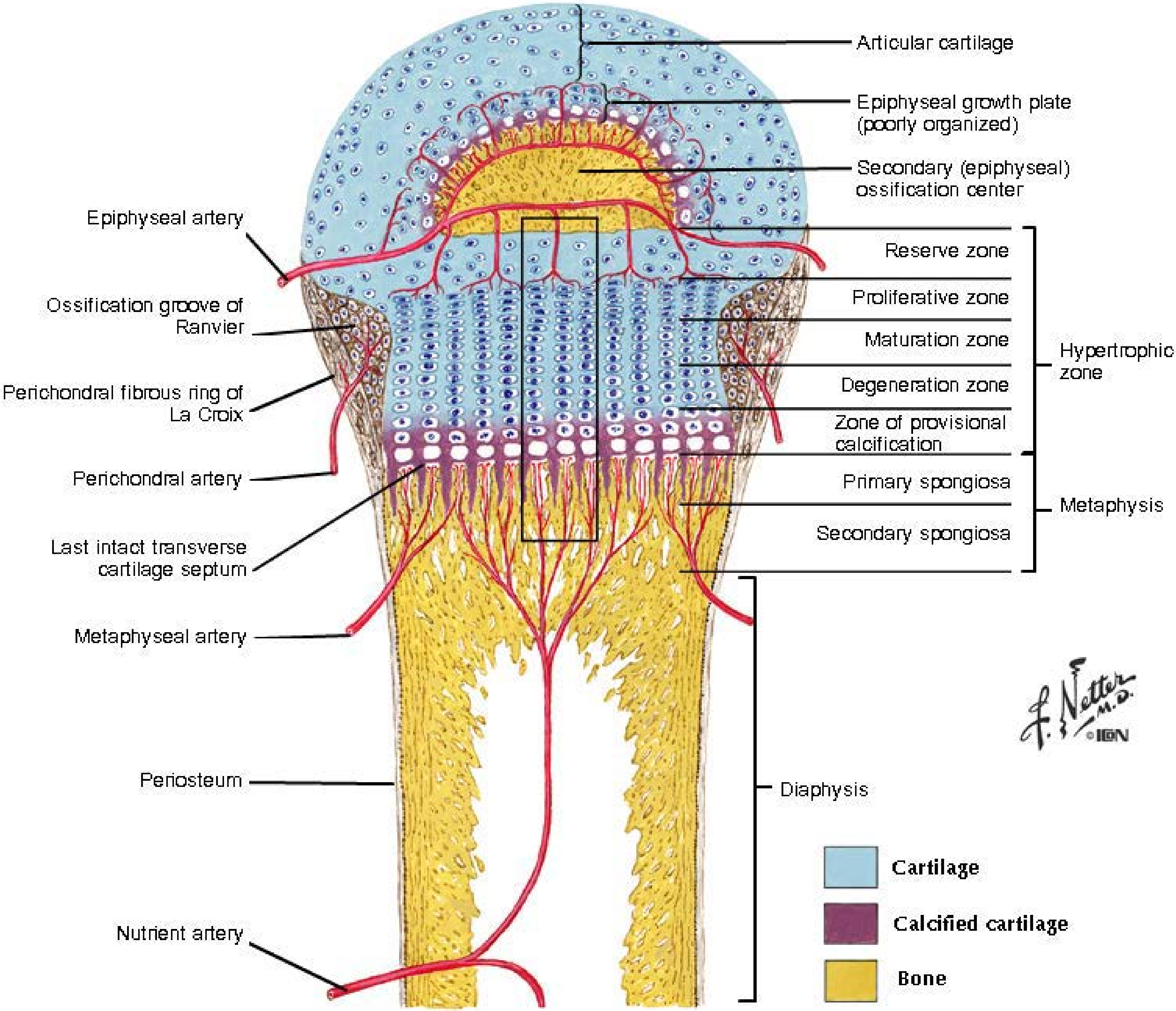


E. At 5 years

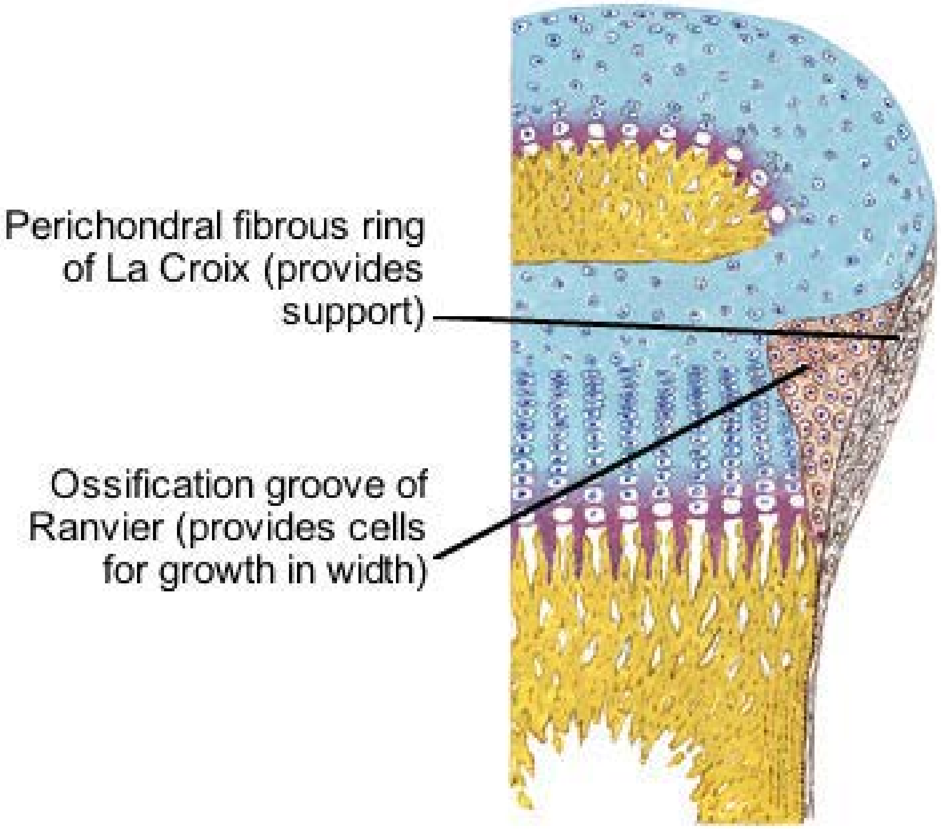
F. At 10 years

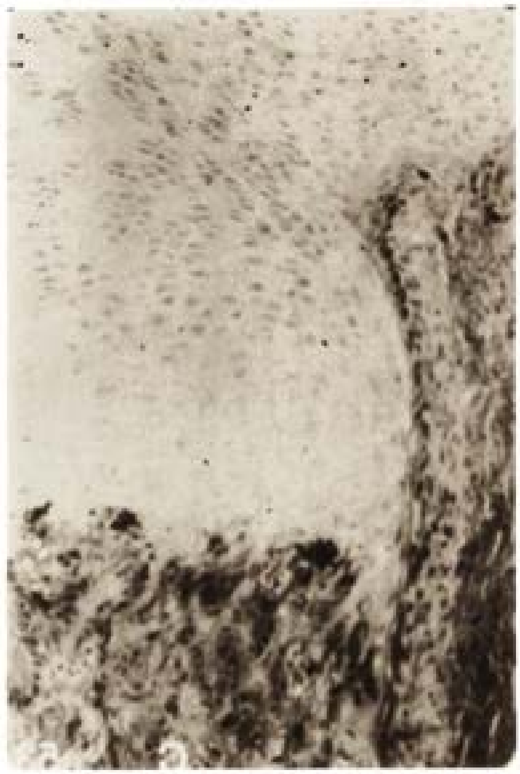
Epiphyseal Growth Plate

Close-up view of developing epiphysis and epiphyseal growth plate



Peripheral Cartilage Function in the Epiphysis
Peripheral fibrocartilaginous element of growth plate





Microscopic section (H&E) corresponds generally to illustration at left

High-power section shows cells of ossification groove of Ranvier apparently "flowing" into cartilage at level of reserve zone, thus contributing to growth in width of growth plate. Note presence of arterioles (cut-in section)

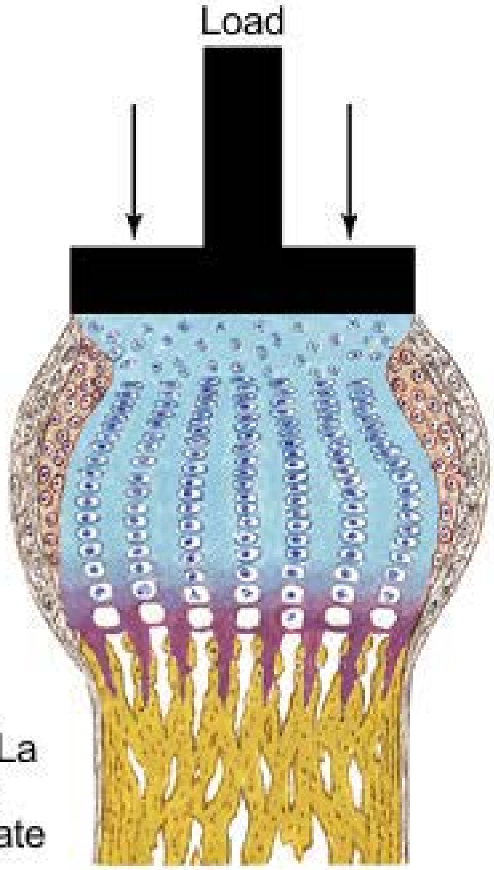
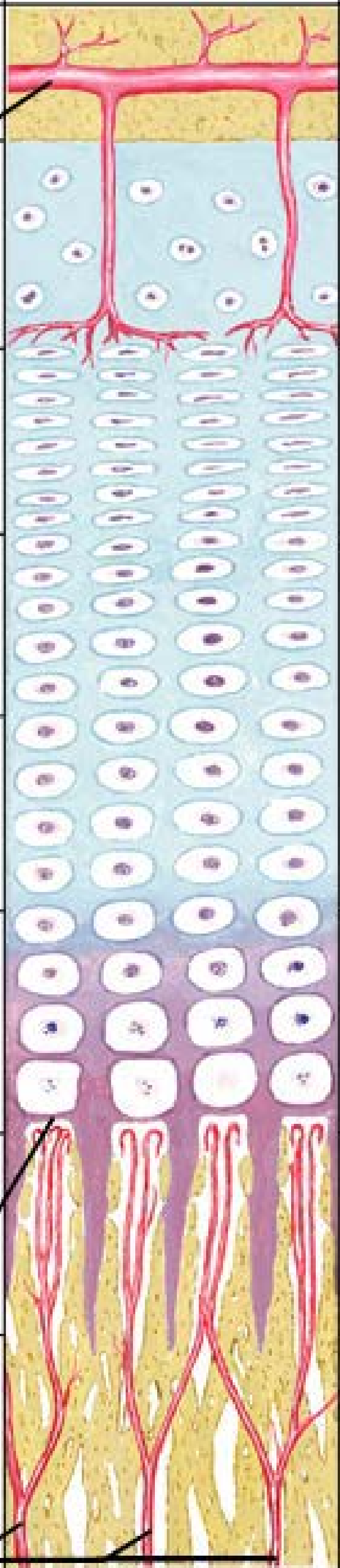
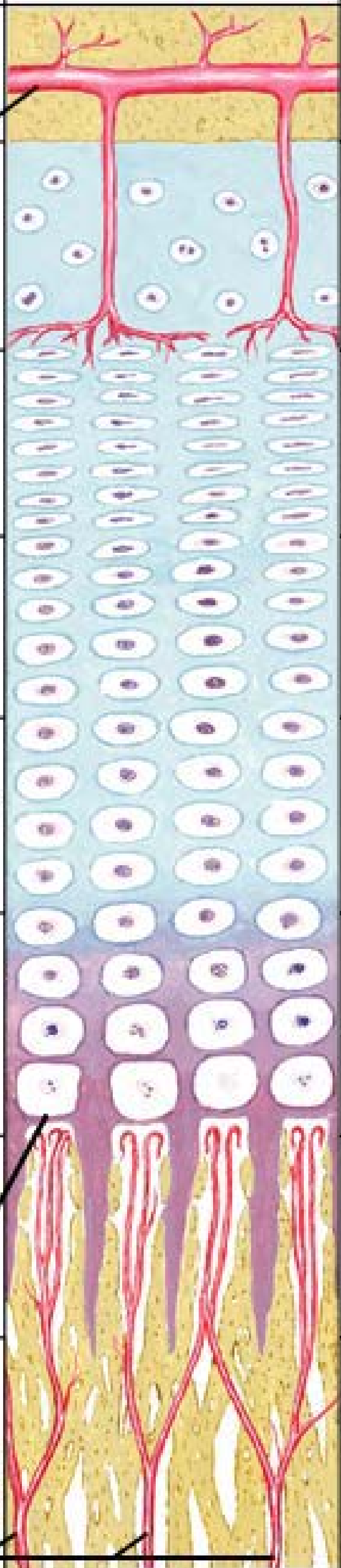


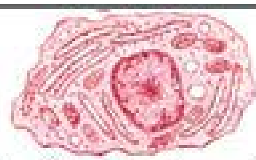
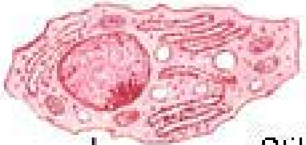
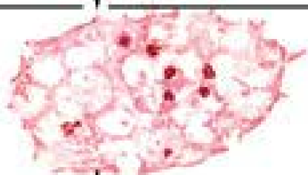
Illustration of how perichondral fibrous ring of La Croix acts as limiting membrane and provides mechanical support to cartilaginous growth plate

Epiphyseal Growth Plate

Zones Structures	Histology	Functions	Blood supply	PO_2
Secondary bony epiphysis Epiphyseal artery				
Reserve zone		Matrix production Storage	Vessels pass through, do not supply this zone	Poor (low)
Proliferative zone		Matrix production Cellular proliferation (longitudinal growth)	Excellent	Excellent Fair
Hypertrophic zone — **Maturation zone**		Preparation of matrix for calcification	*Progressive decrease*	Poor (low)
Hypertrophic zone — **Degenerative zone**				*Progressive decrease*
Hypertrophic zone — Zone of provisional calcification		Calcification of matrix	Nil	Poor (very low)
Metaphysis — Last intact transverse septum **Primary spongiosa**		Vascular invasion and resorption of transverse septa Bone formation	Closed capillary loops Good	Poor Good
Metaphysis — **Secondary spongiosa** Branches of metaphyseal and nutrient arteries		Remodeling Internal: removal of cartilage bars, replacement of fiber bone with lamellar bone External: funnelization	Excellent	Excellent

Epiphyseal Growth Plate



Zones Structures	Cell (chondrocyte) health	Cell respiration	Cell glycogen
Secondary bony epiphysis Epiphyseal artery			
Reserve zone	 Good, active. Much endoplasmic reticulum, vacuoles, mitochondria	Anaerobic	High concentration
Proliferative zone	 Excellent. Much endoplasmic reticulum, ribosomes, mito-chondria. Intact cell membrane	Aerobic	High concentration (less than in above)
Hypertrophic zone – **Maturation zone**	 Still good	*Progressive change to anaerobic*	*Glycogen consumed until depleted*
Hypertrophic zone – **Degenerative zone**	Progressive deterioration	Anaerobic glycolysis	
Hypertrophic zone – **Zone of provisional calcification**	 Cell death	Anaerobic glycolysis	Nil
Metaphysis – Last intact transverse septum **Primary spongiosa**		*Progressive reversion to aerobic*	?
Metaphysis – **Secondary spongiosa** Branches of metaphyseal and nutrient arteries		Aerobic	?

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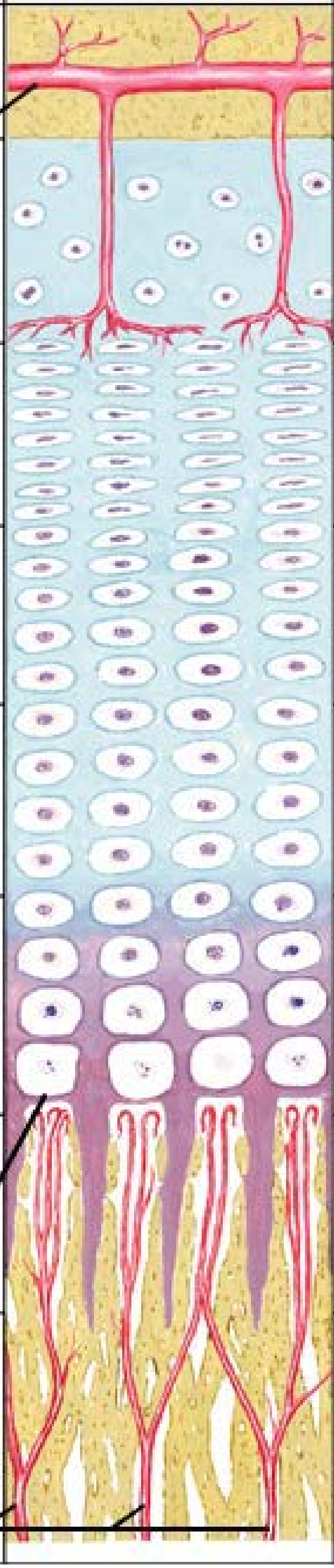
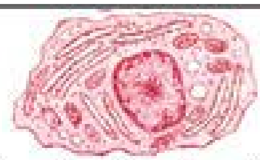
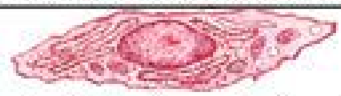
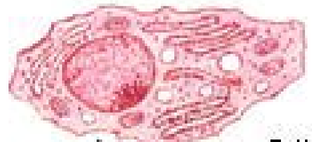
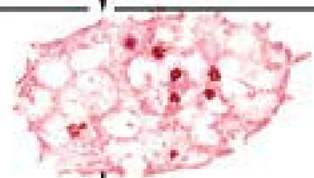
Epiphyseal Growth Plate

Zones Structures	Histology	Cell (chondrocyte) health	Cell respiration	Cell glycogen
Secondary bony epiphysis Epiphyseal artery				
Reserve zone		 Good, active. Much endoplasmic reticulum, vacuoles, mitochondria	Anaerobic	High concentration
Proliferative zone		 Excellent. Much endoplasmic reticulum, ribosomes, mitochondria. Intact cell membrane	Aerobic	High concentration (less than in above)
Hypertrophic zone – **Maturation zone**		 Still good	*Progressive change to anaerobic*	*Glycogen consumed until depleted*
Hypertrophic zone – **Degenerative zone**		Progressive deterioration	Anaerobic glycolysis	
Hypertrophic zone – **Zone of provisional calcification**		 Cell death	Anaerobic glycolysis	Nil
Metaphysis – Last intact transverse septum **Primary spongiosa**			*Progressive reversion to aerobic*	?
Metaphysis – **Secondary spongiosa** Branches of metaphyseal and nutrient arteries			Aerobic	?

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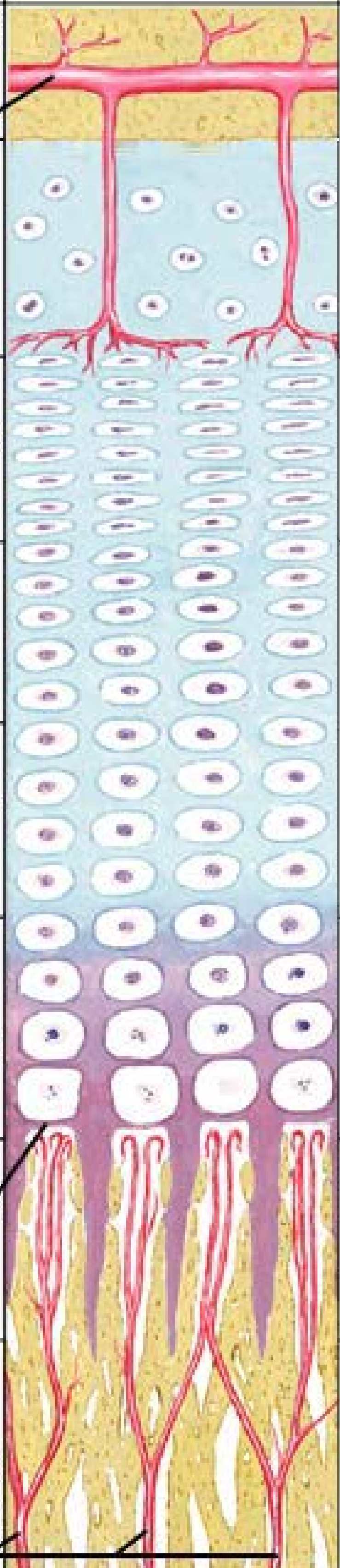
Eqiphyseal Growth Plate

Zones Structures	**Histology**	**Exemplary diseases**	**Defect** (if known)
Secondary bony epiphysis Epiphyseal artery			
Reserve zone		Diastrophic dwarfism (also, defects in other zones)	Defective type II collagen synthesis
		Pseudoachondroplasia (also, defects in other zones)	Defective processing and transport of proteoglycans
		Kniest syndrome (also, defects in other zones)	Defective processing of proteoglycans
Proliferative zone		Gigantism	Increased cell proliferation (growth hormone increased)
		Achondroplasia	Deficiency of cell proliferation
		Hypochondroplasia	Less severe deficiency of cell proliferation
		Malnutrition, irradiation injury, glucocorticoid excess	Decreased cell proliferation and/or matrix synthesis
Hypertrophic zone: **Maturation zone**, **Degenerative zone**		Mucopolysaccharidosis (Morquio's syndrome, Hurler's syndrome)	Deficiencies of specific lysosomal acid hydrolases, with lysosomal storage of mucopolysaccharides
Hypertrophic zone: **Zone of provisional calcification**		Rickets, osteomalacia also, defects in metaphysis)	Insufficiency of Ca^{2+} and/or P_i for normal calcification of matrix
Metaphysis: Last intact tranverse septum; **Primary spongiosa**		Metaphyseal chondrodysplasia (Jansen and Schmid types)	Extension of hypertrophic cells into metaphysis
		Acute hematogenous osteomyelitis	Flourishing of bacteria due to sluggish circulation, low P_{O_2}, reticuloendothelial deficiency
Metaphysis: **Secondary spongiosa**; Branches of metaphyseal and nutrient arteries		Osteopetrosis	Abnormality of osteoclasts (internal remodeling)
		Osteogenesis imperfecta	Abnormality of osteoblasts and collagen synthesis
		Scurvy	Inadequate collagen formation
		Metaphyseal dysplasia (Pyle disease)	Abnormality of funnelization (external remodeling)

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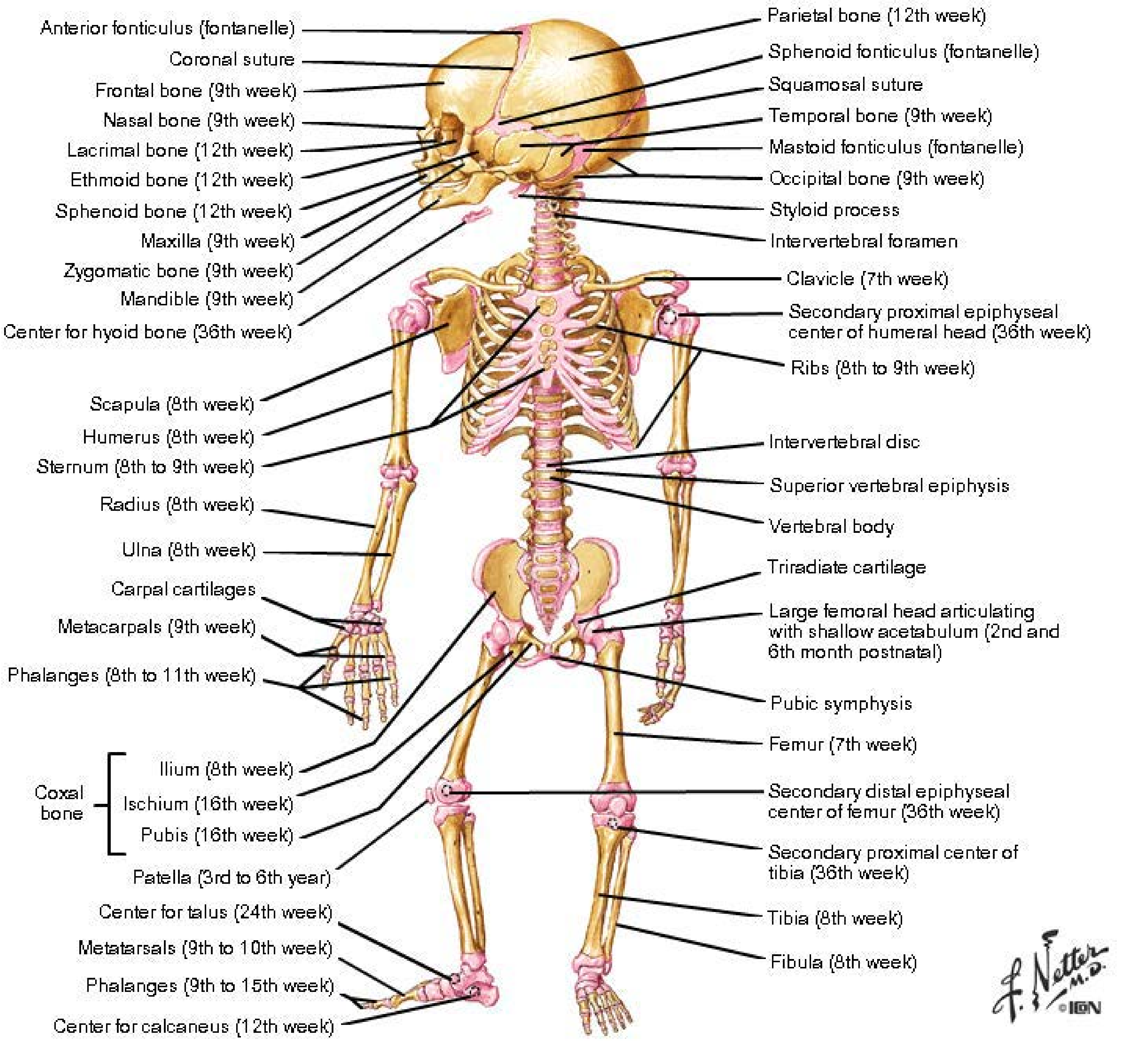
Ossification in the Newborn Skeleton

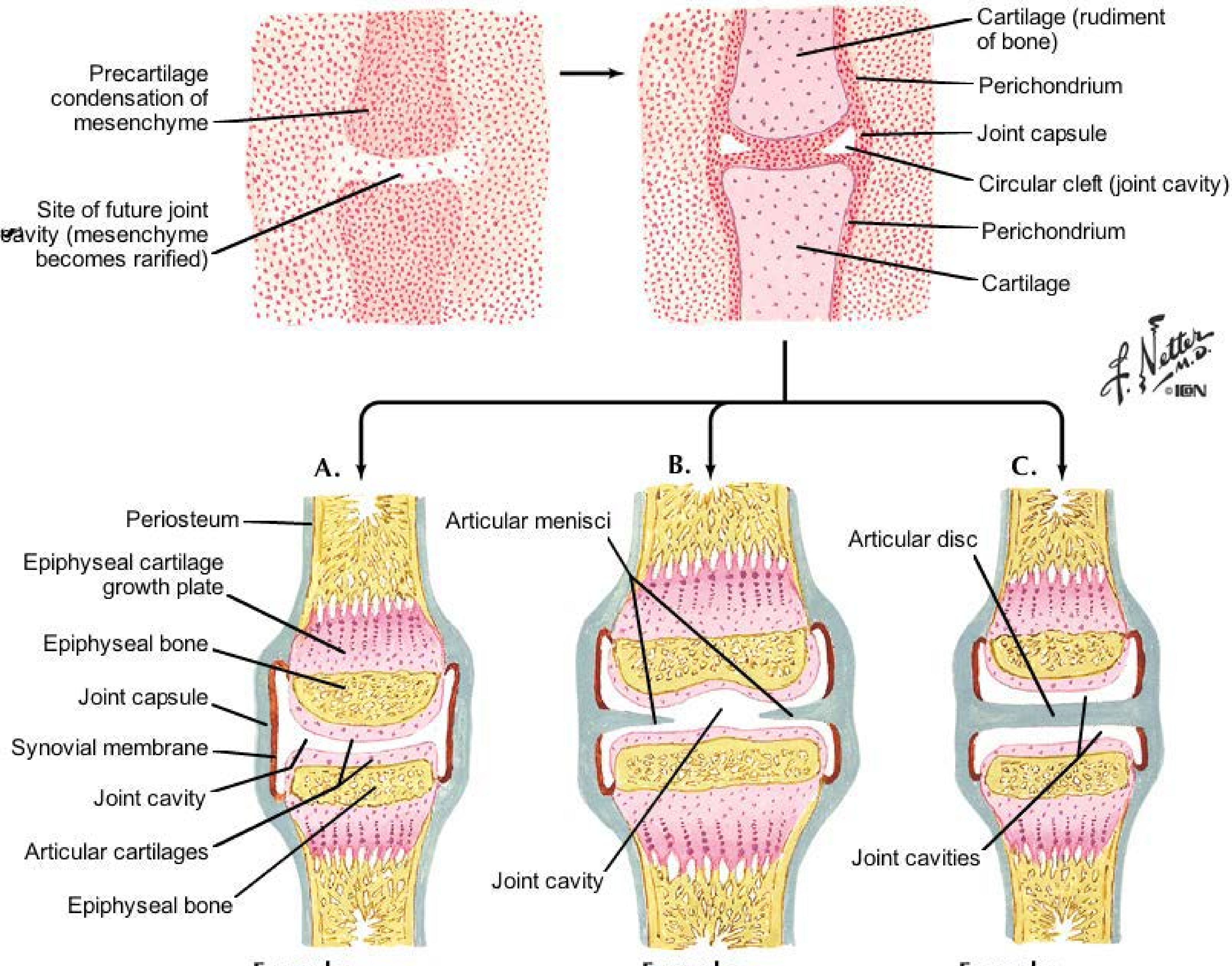
Skeleton of full-term newborn

Time of appearance of ossification centers (primary unless otherwise indicated)



Joint Development

Development of three types of synovial joints



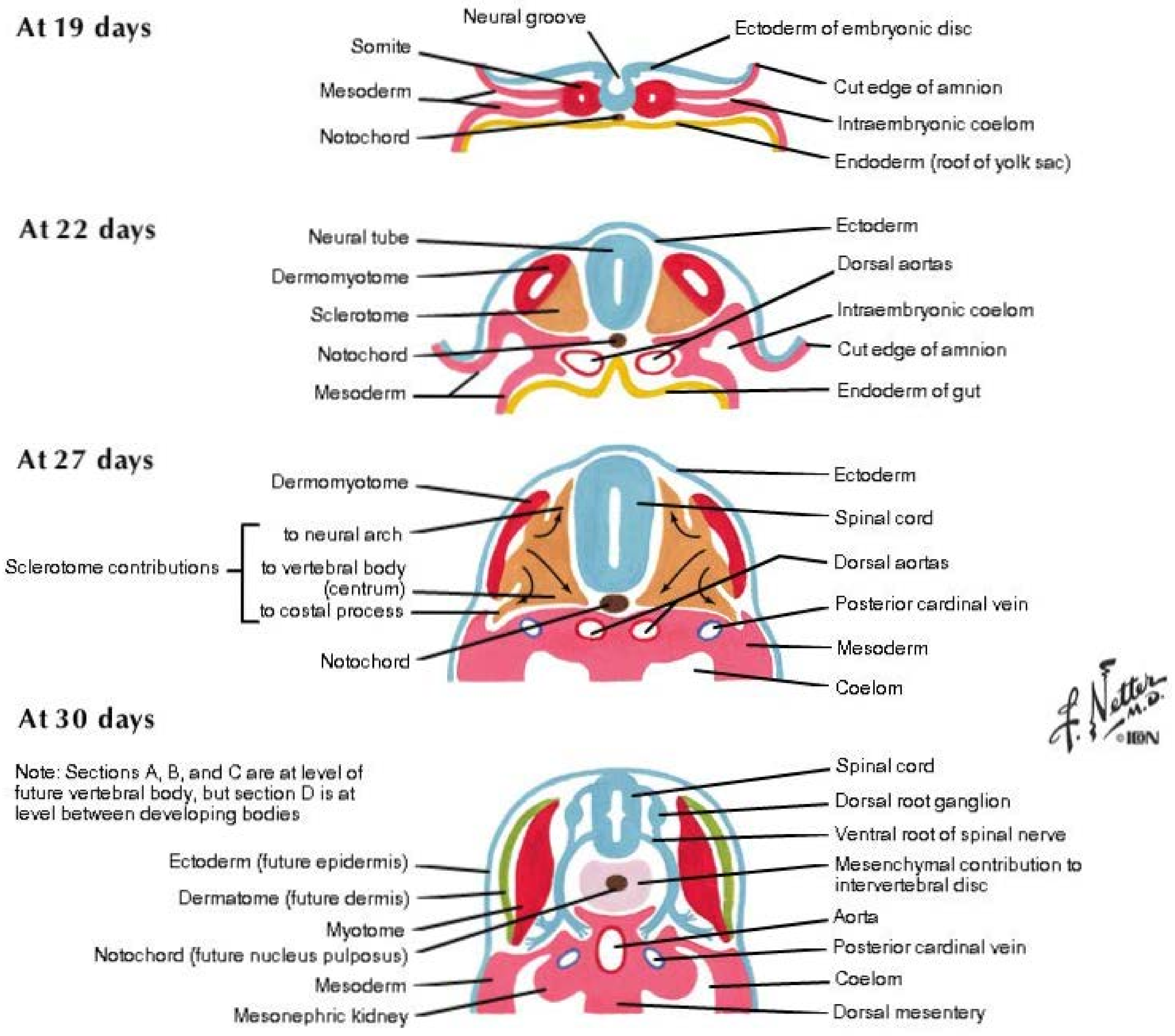
Example: interphalangeal joint

Example: knee joint

Example: sternoclavicular joint

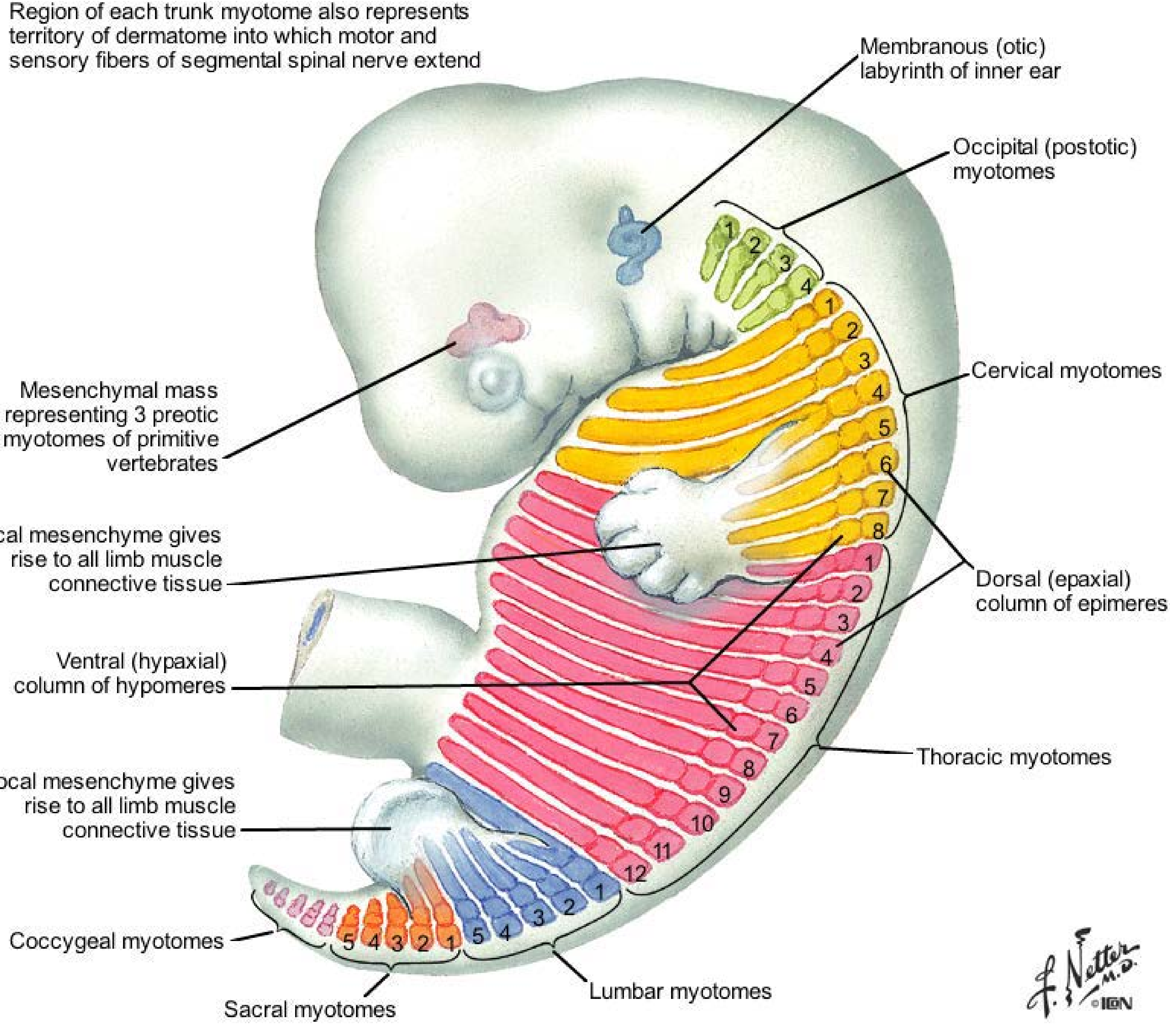
Muscular System: Primordia

Differentiation of somites into myotomes, sclerotomes, and dermatomes
Cross section of human embryos

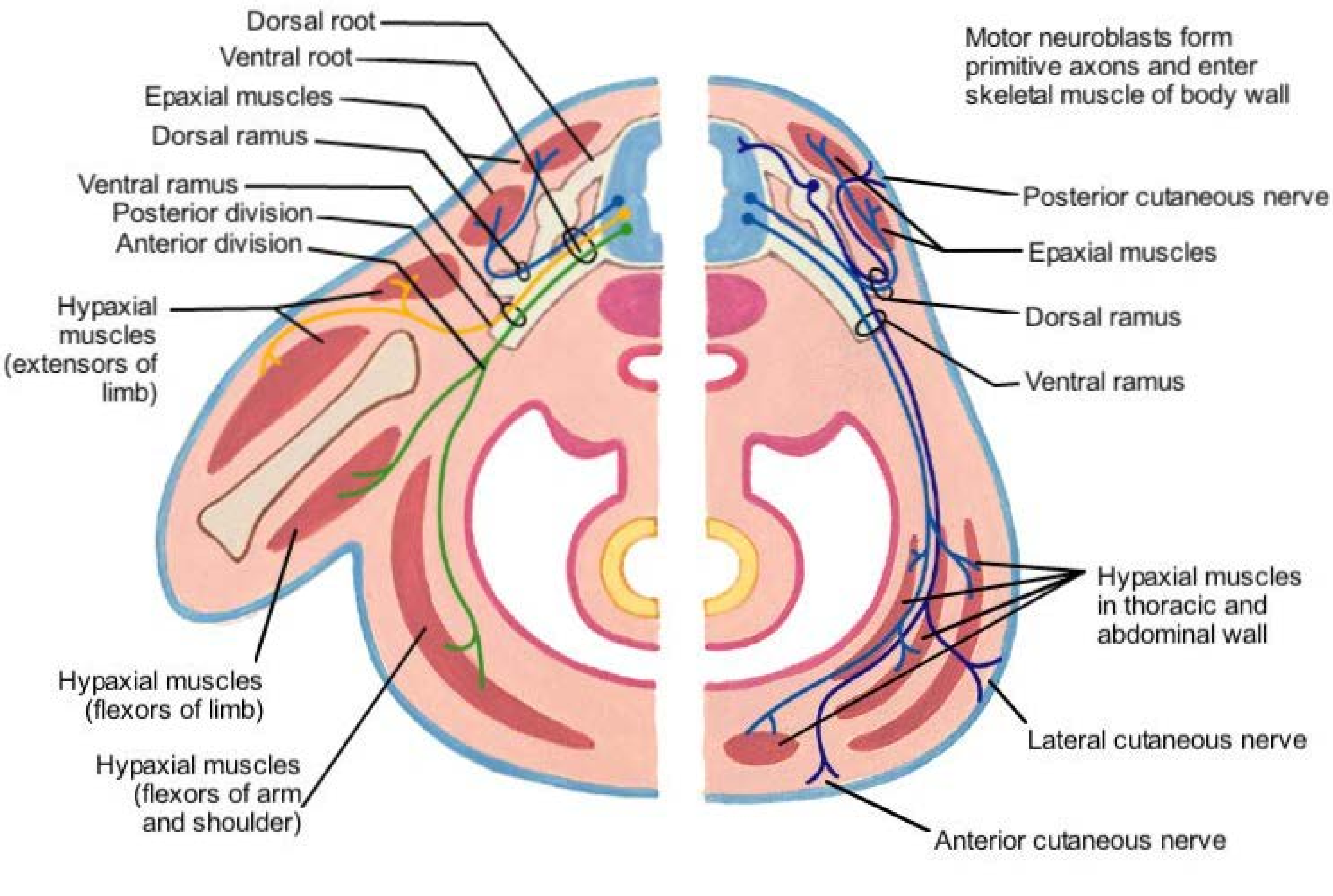


Segmentation and Division of Myotomes

Segmental distribution of myotomes in fetus of 6 weeks



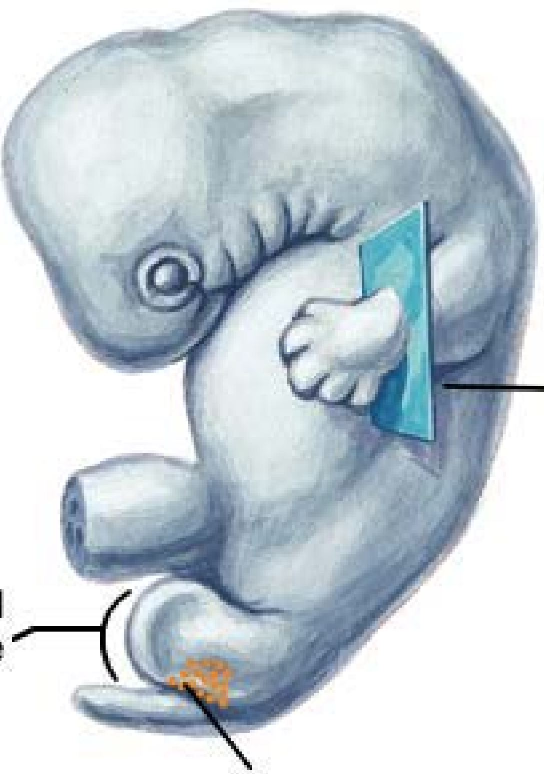
Epimere, Hypomere, and Muscle Groups
Somatic development



Somatic nervous system innervates somatopleure (body wall)

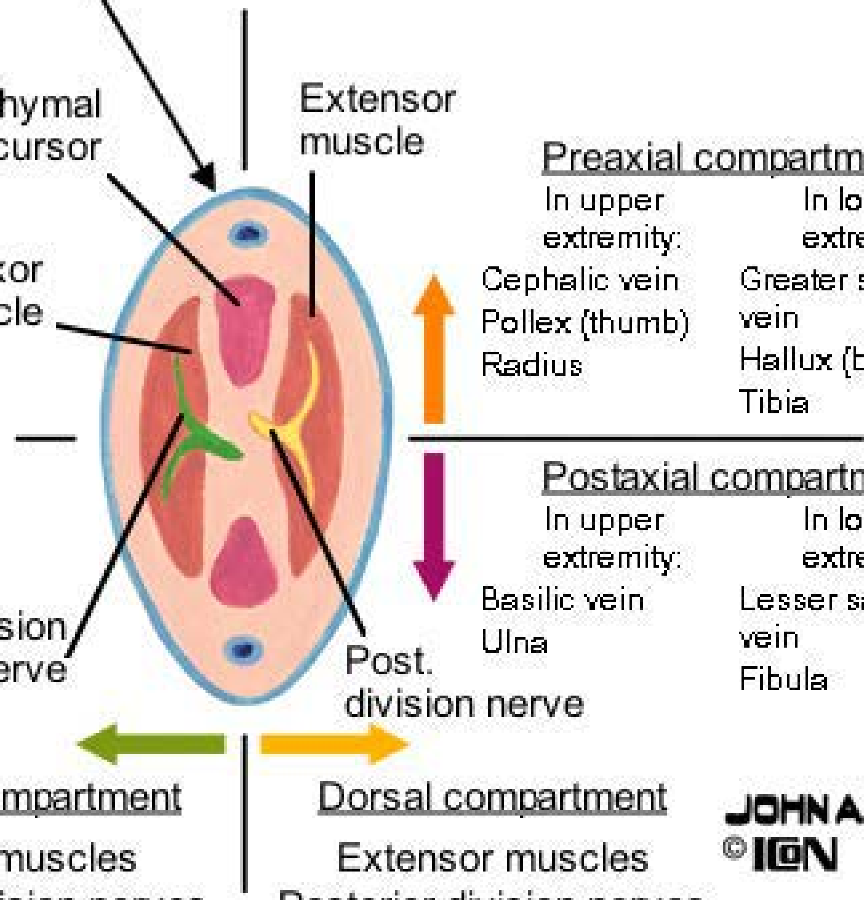
Development and Organization of Limb Buds

Limb buds in 6-week embryo



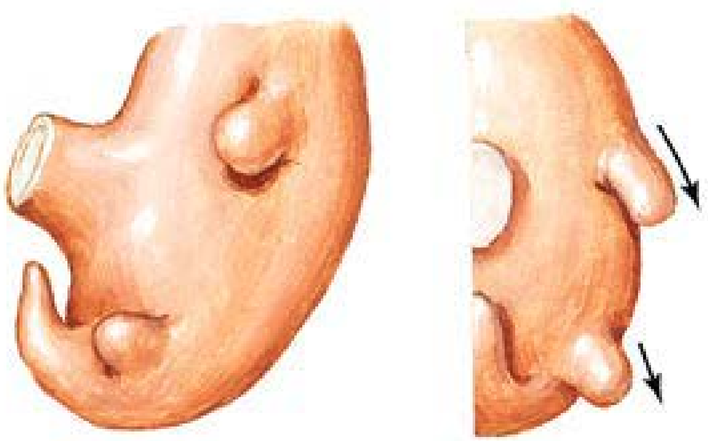
In the classic model of proximodistal morphological determination, the apical ectodermal ridge interacts with the underlying mesoderm of the progress zone to establish a time sequence of differentiation as the limb elongates. More recent evidence indicates that the morphological information may be programmed early on in the mesenchyme with no particular role for the ectoderm.

Early craniocaudal morphological differentiation is determined by a gradient of sonic hedgehog produced by the zone of polarizing activity (ZPA), a signaling center at the caudal end of each limb bud. The ZPA also stimulates the formation of the apical ectodermal ridge.

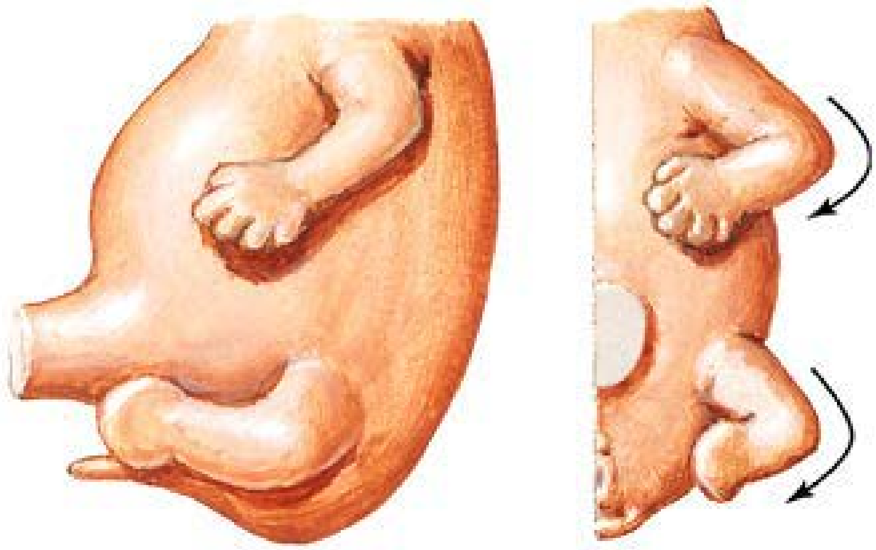


Rotation of the Limbs

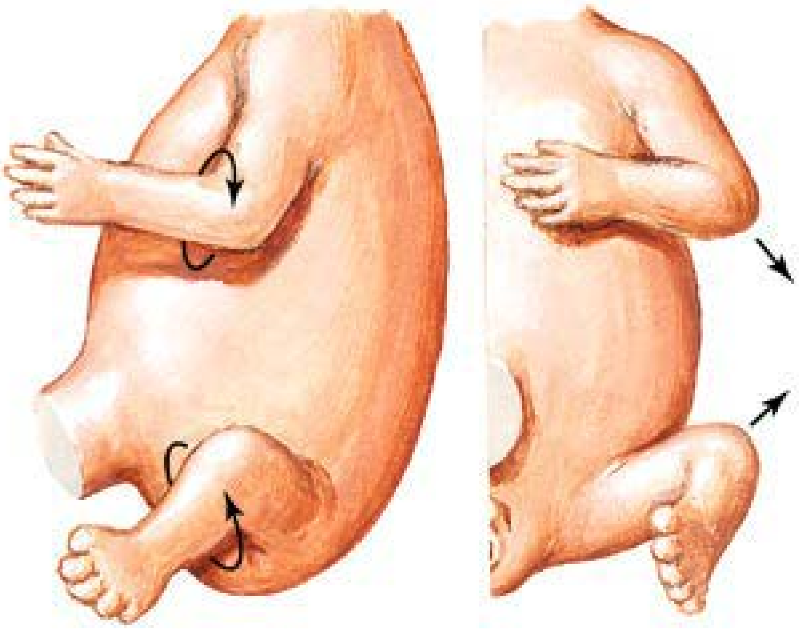
Changes in position of limbs before birth



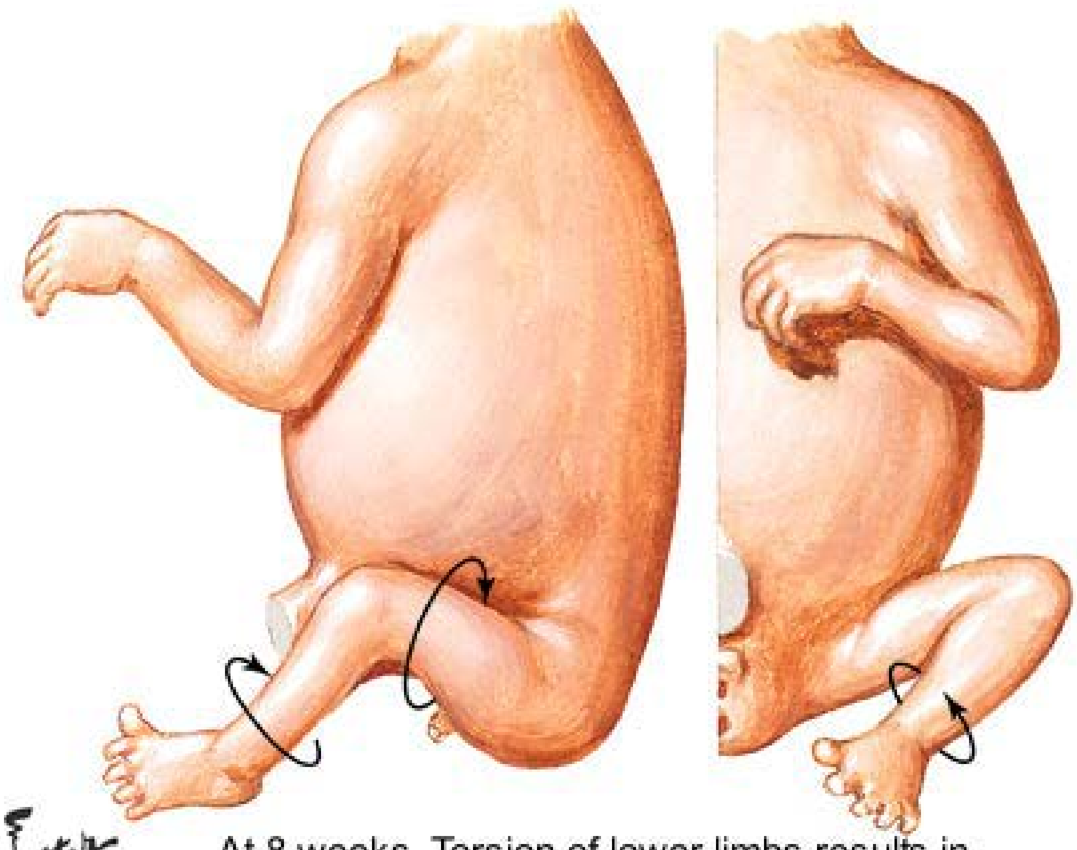
At 5 weeks. Upper and lower limbs have formed as finlike appendages pointing laterally and caudally



At 6 weeks. Limbs bend anteriorly, so elbows and knees point laterally, palms and soles face trunk



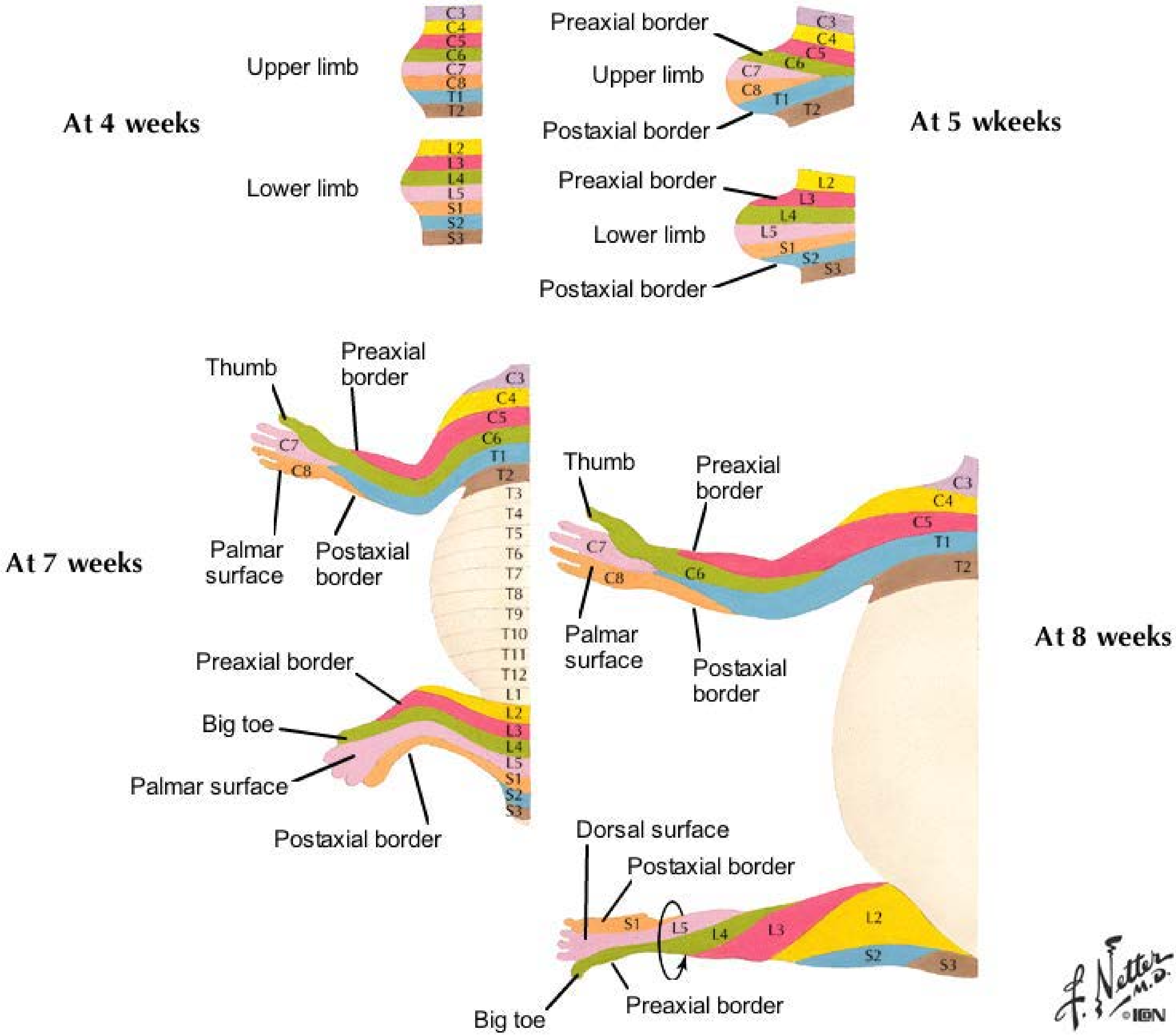
At 7 weeks. Upper and lower limbs have undergone 90-degree torsion about their long axes, but in opposite directions, so elbows point caudally and knees cranially



At 8 weeks. Torsion of lower limbs results in twisted or "barber pole" arrangement of their cutaneous innervation

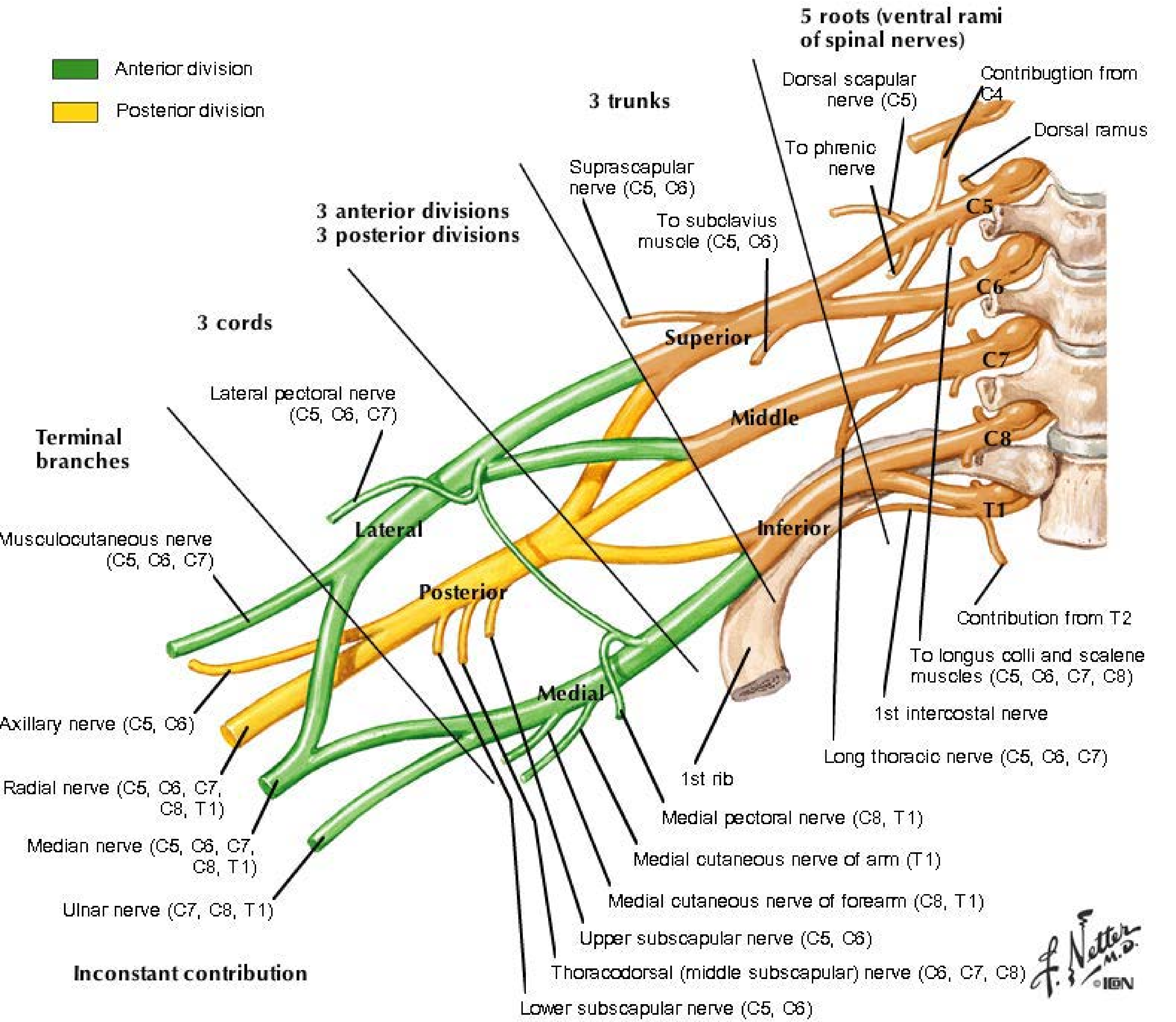
Limb Rotation and Dermatomes

Changes in ventral dermatome pattern (cutaneous sensory nerve distribution) during limb development

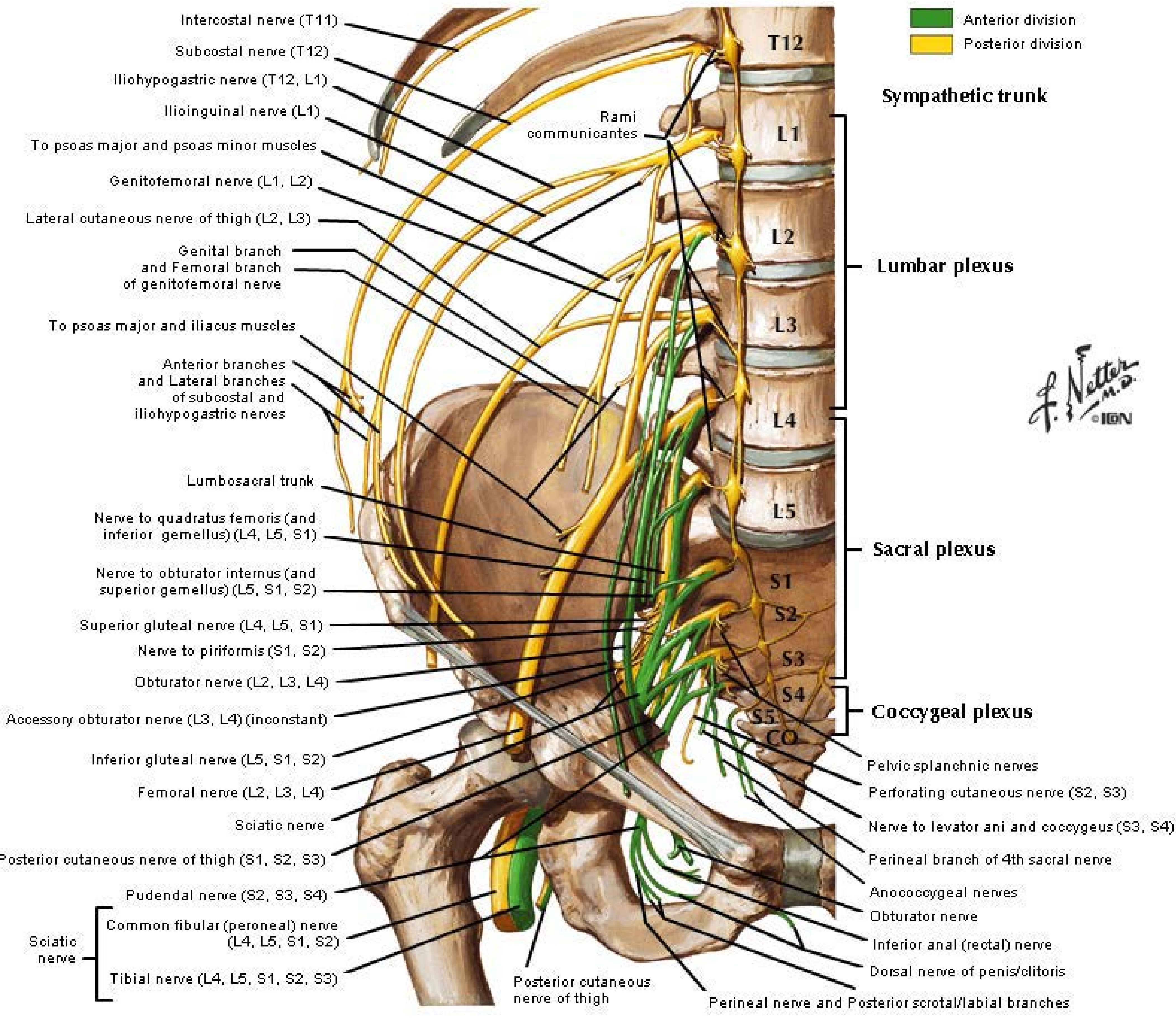


Embryonic Plan of the Brachial Plexus

Comparison of embryonic limb organization to the plan of the brachial plexus

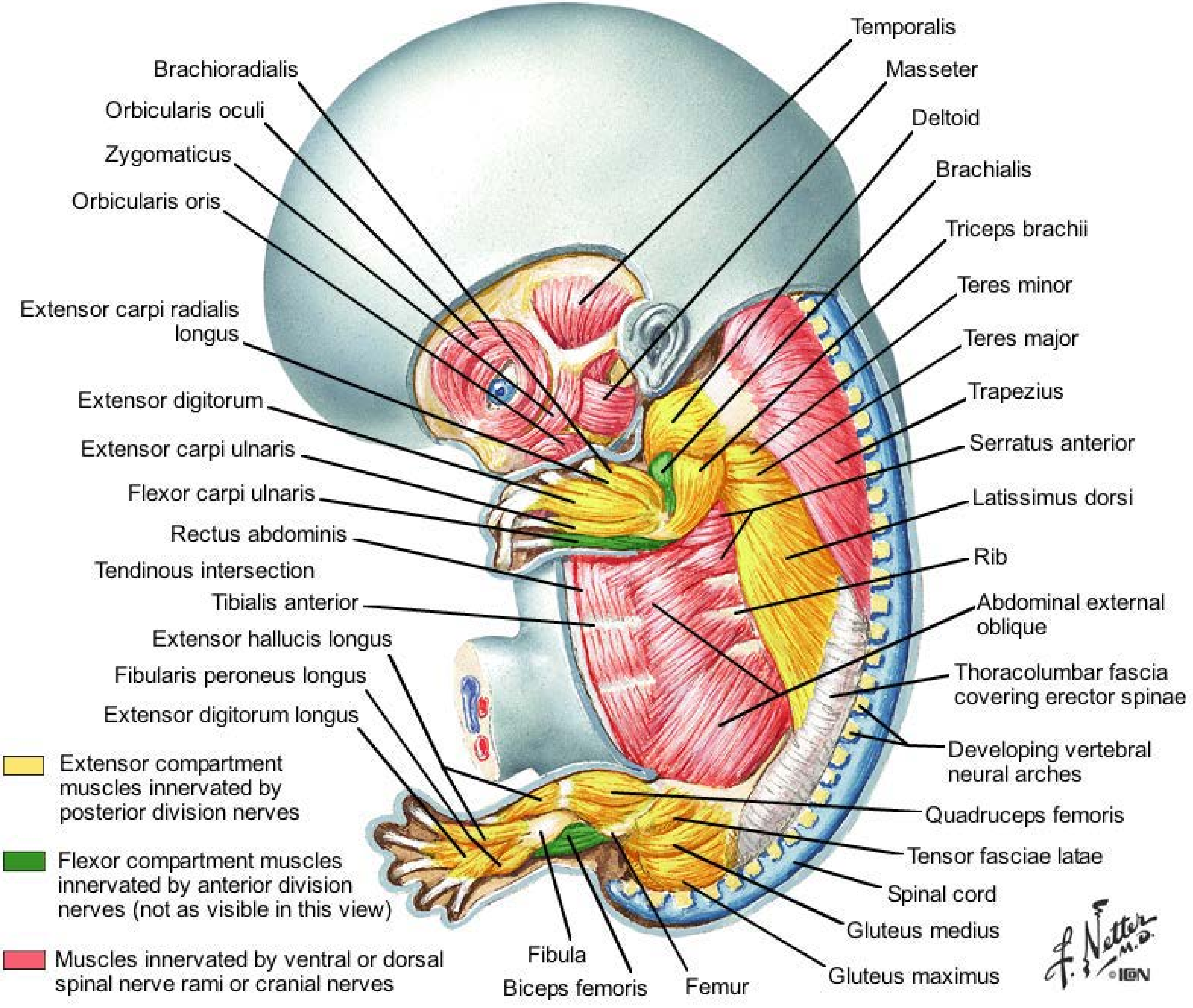


Divisions of the Lumbosacral Plexus

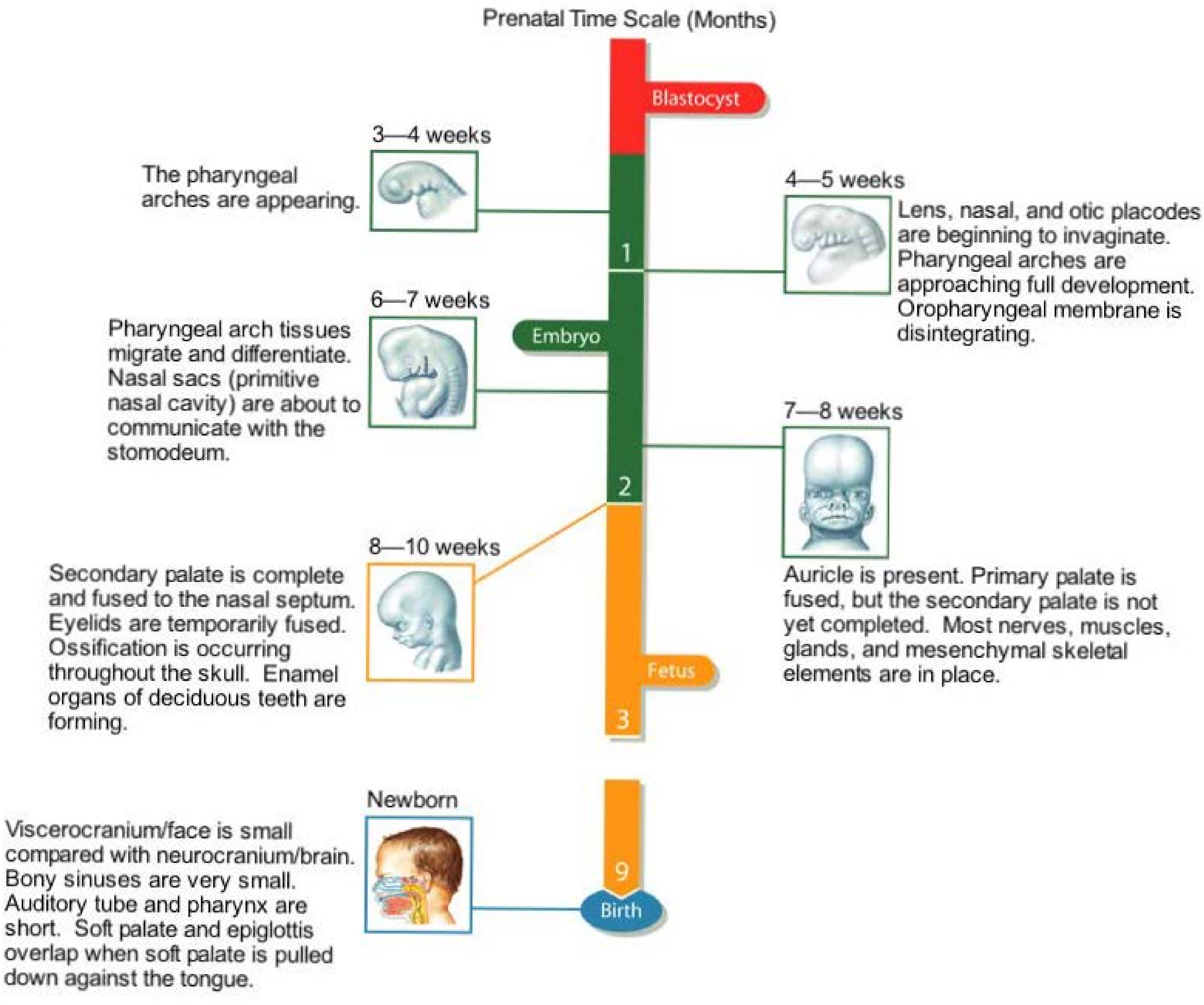


Developing Skeletal Muscles

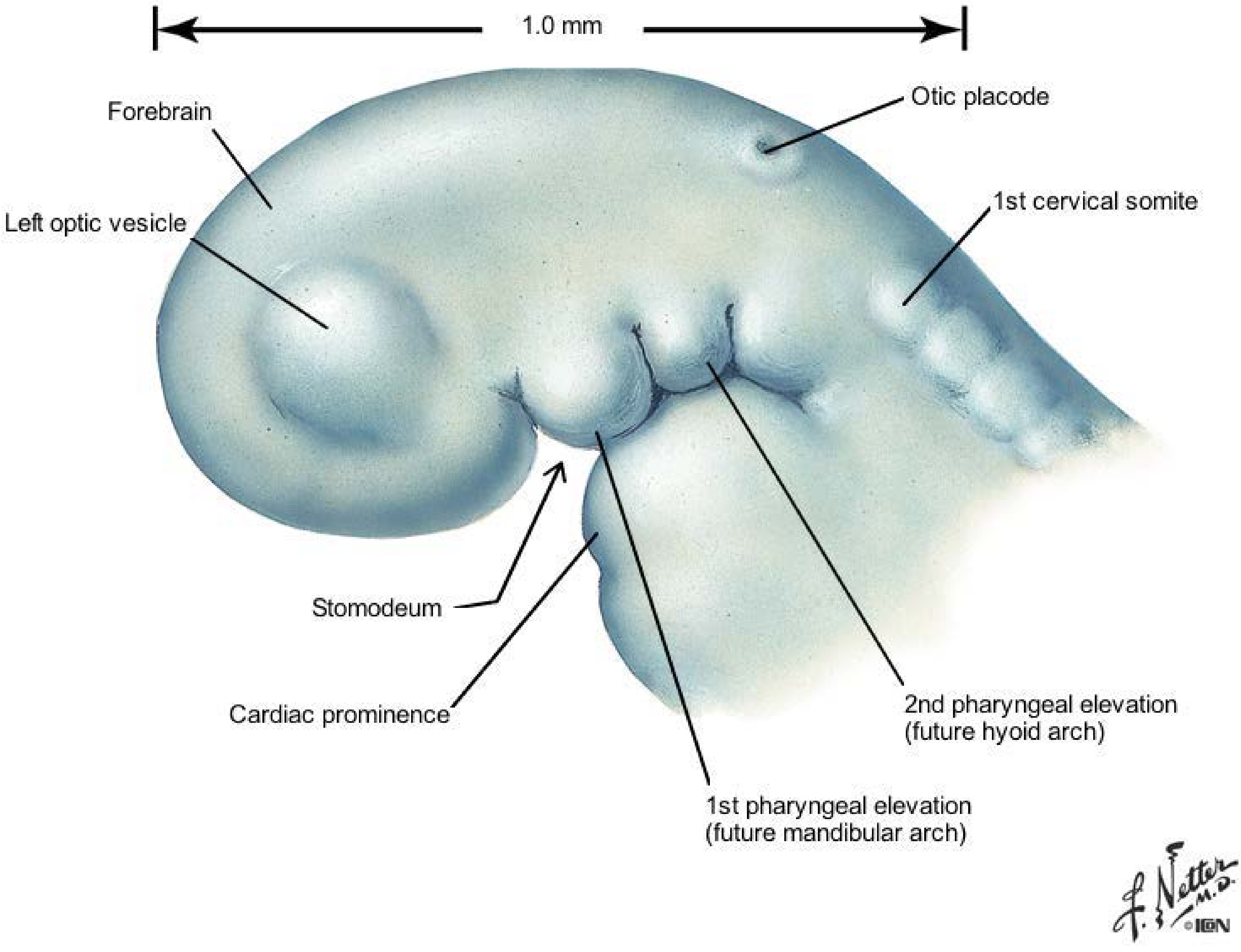
Developing skeletal muscles at 8 weeks (superficial exposure)



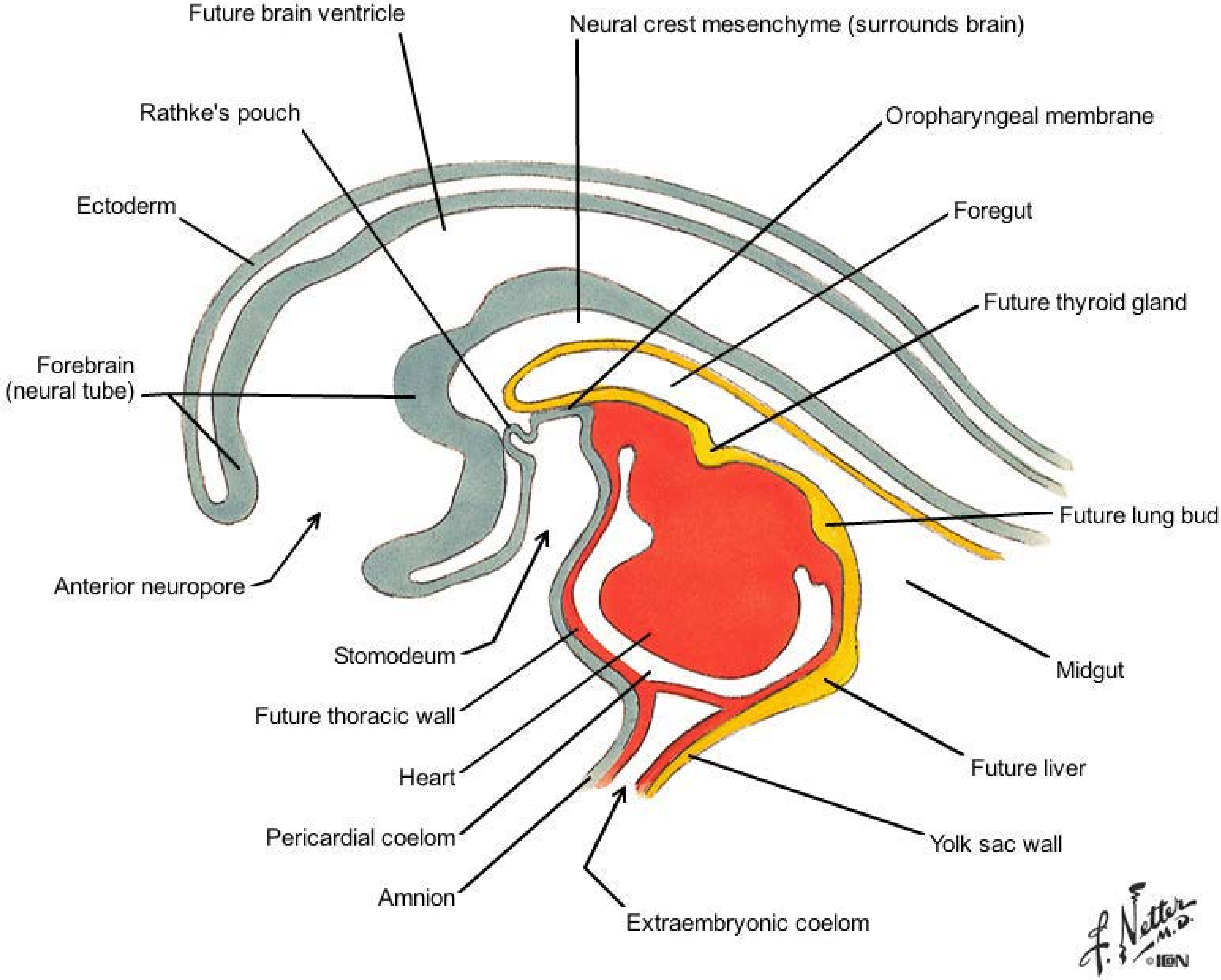
HEAD AND NECK
TIMELINE



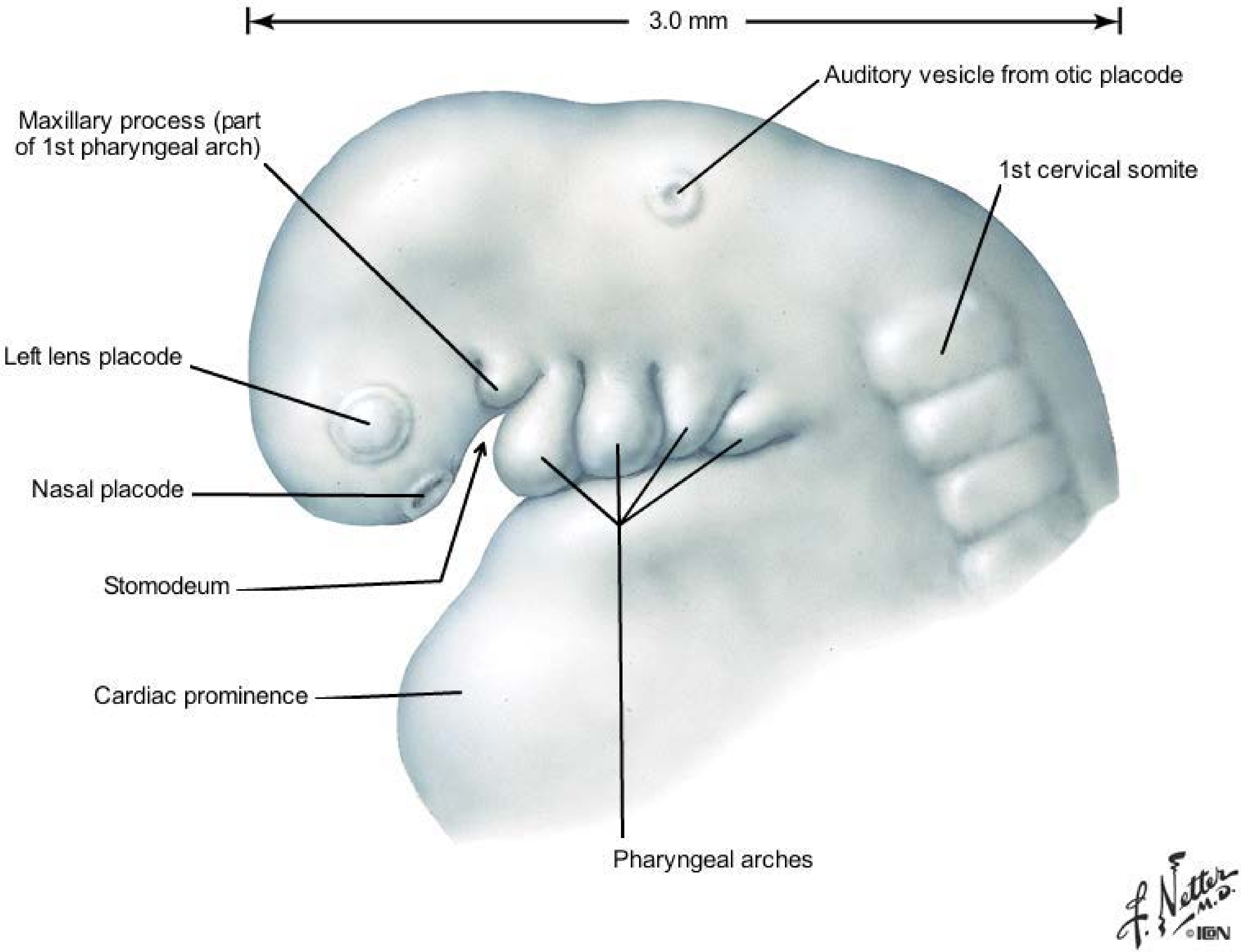
Ectoderm, Endoderm, and Mesoderm
Lateral view (3 to 4 weeks)



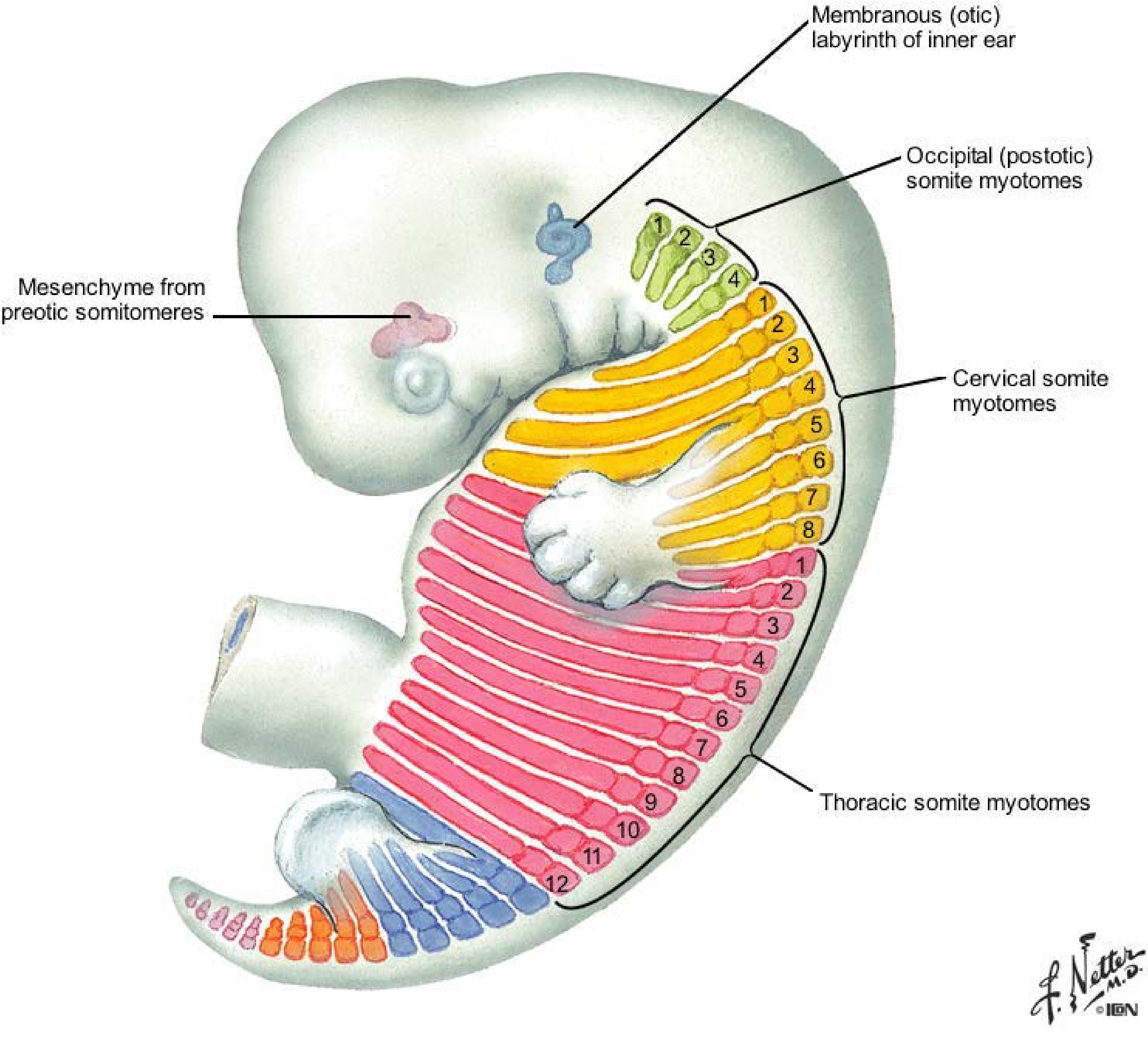
Ectoderm, Endoderm, and Mesoderm
Sagittal section (3 to 4 weeks)



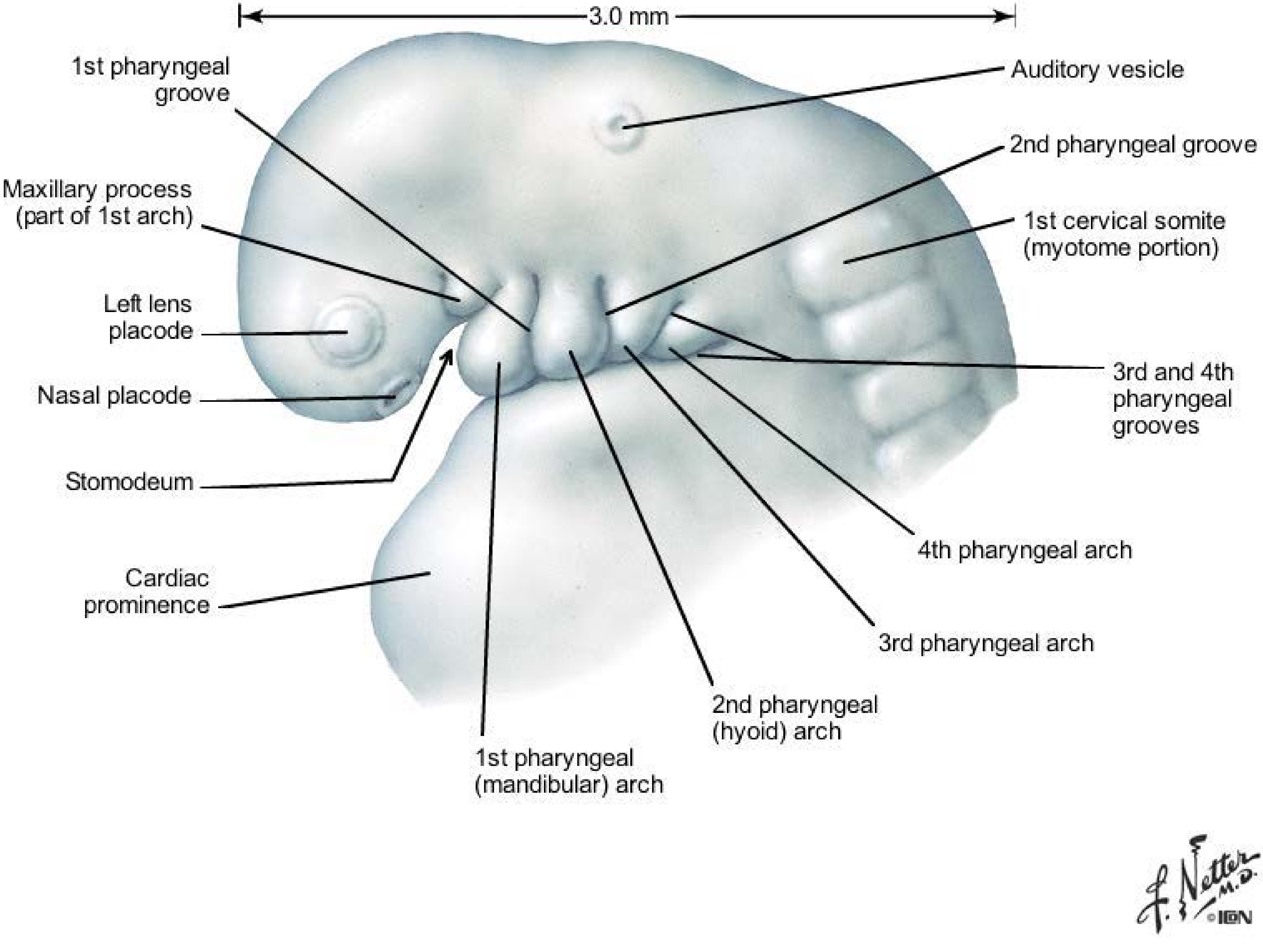
Ectoderm, Endoderm, and Mesoderm
Lateral view (4 to 5 weeks)



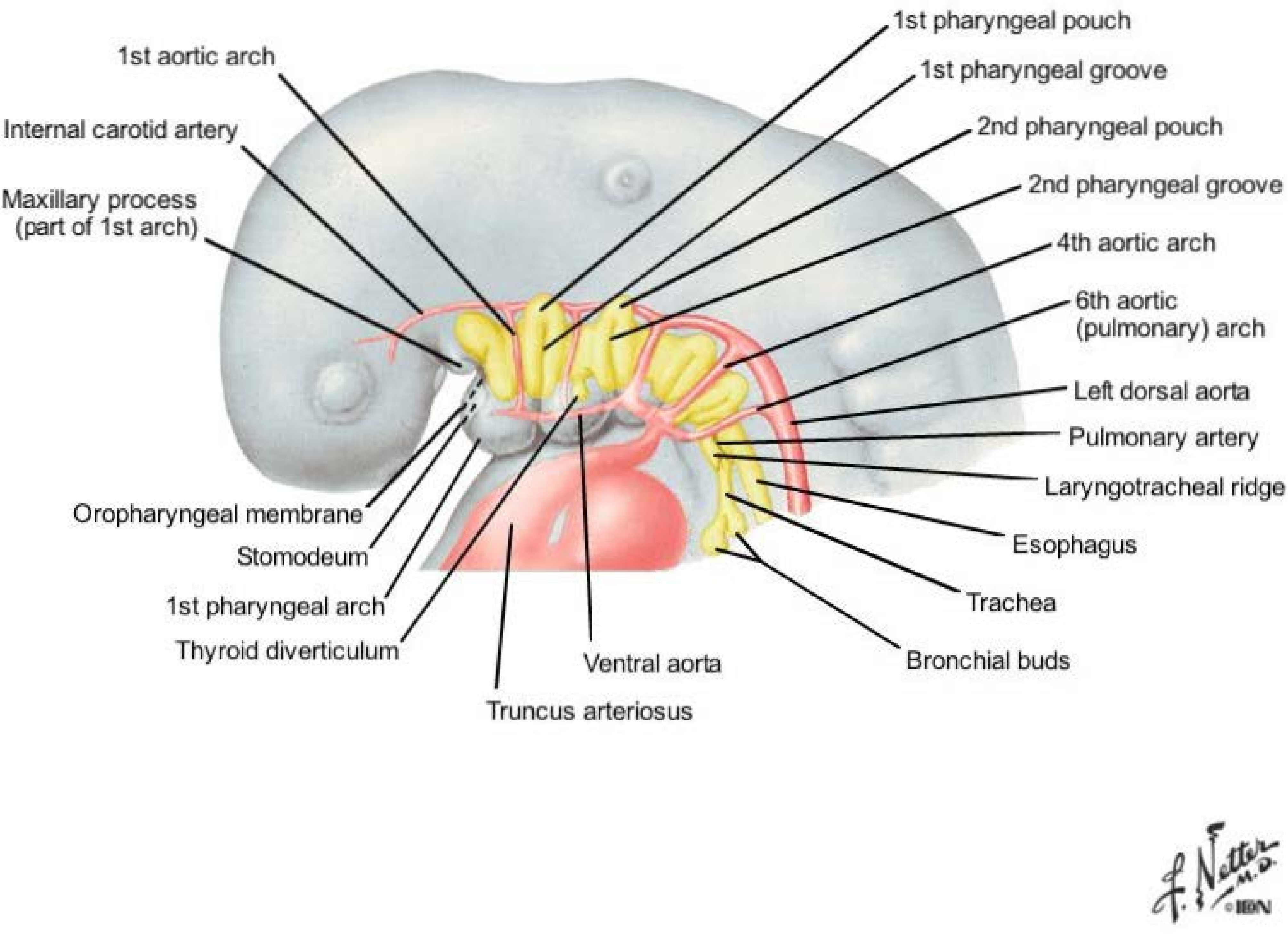
Ectoderm, Endoderm, and Mesoderm
Somites and somitomeres (6 weeks)



Pharyngeal (Branchial) Arches
Embryo at 4 to 5 weeks
Lateral View

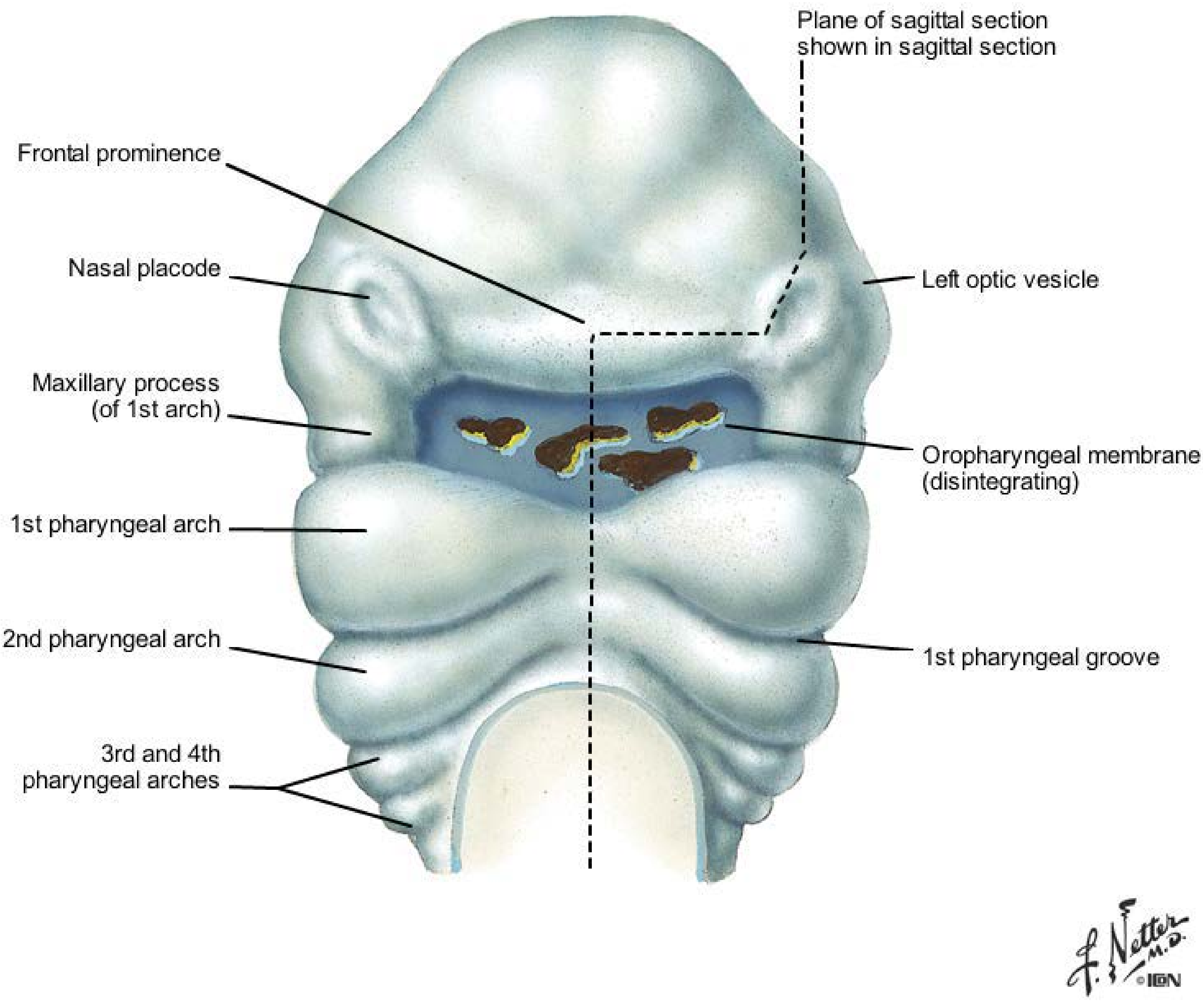


Pharyngeal (Branchial) Arches
Pharyngeal pouches and aortic arch arteries
Lateral View



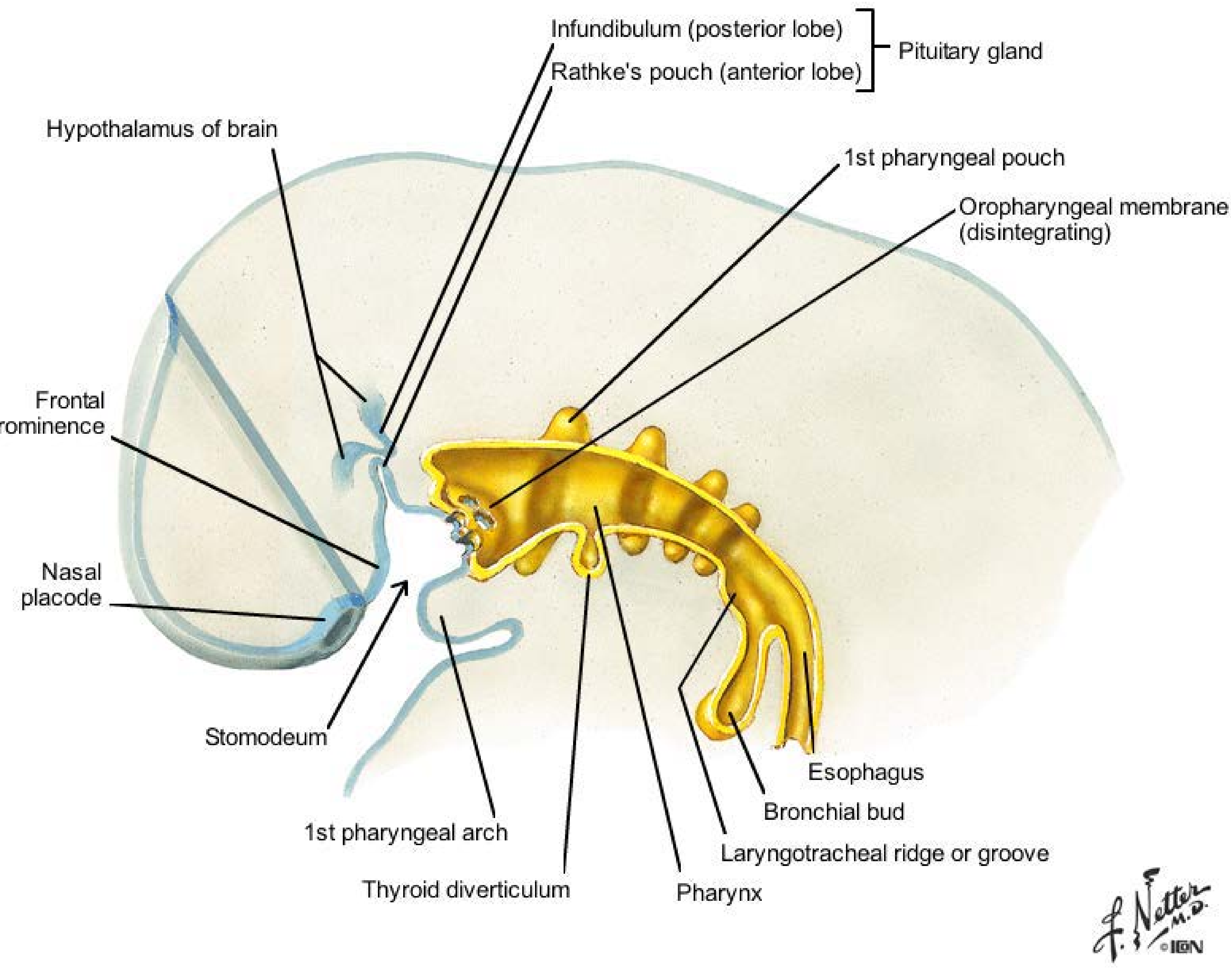
Ventral and Midsagittal Views
Embryo at 4 to 5 weeks

Ventral view

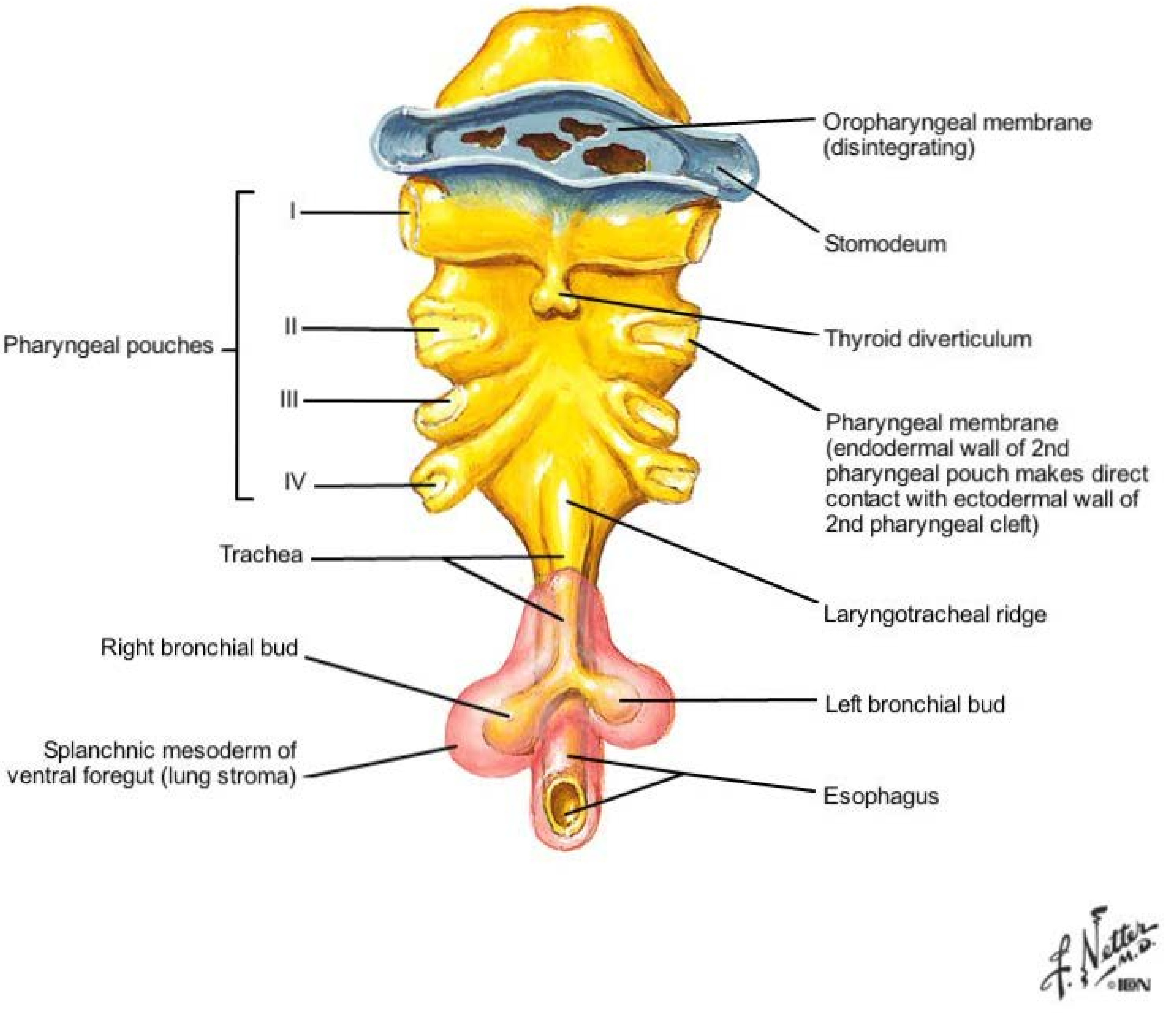


Ventral and Midsagittal Views
Embryo at 4 to 5 weeks

Sagittal section

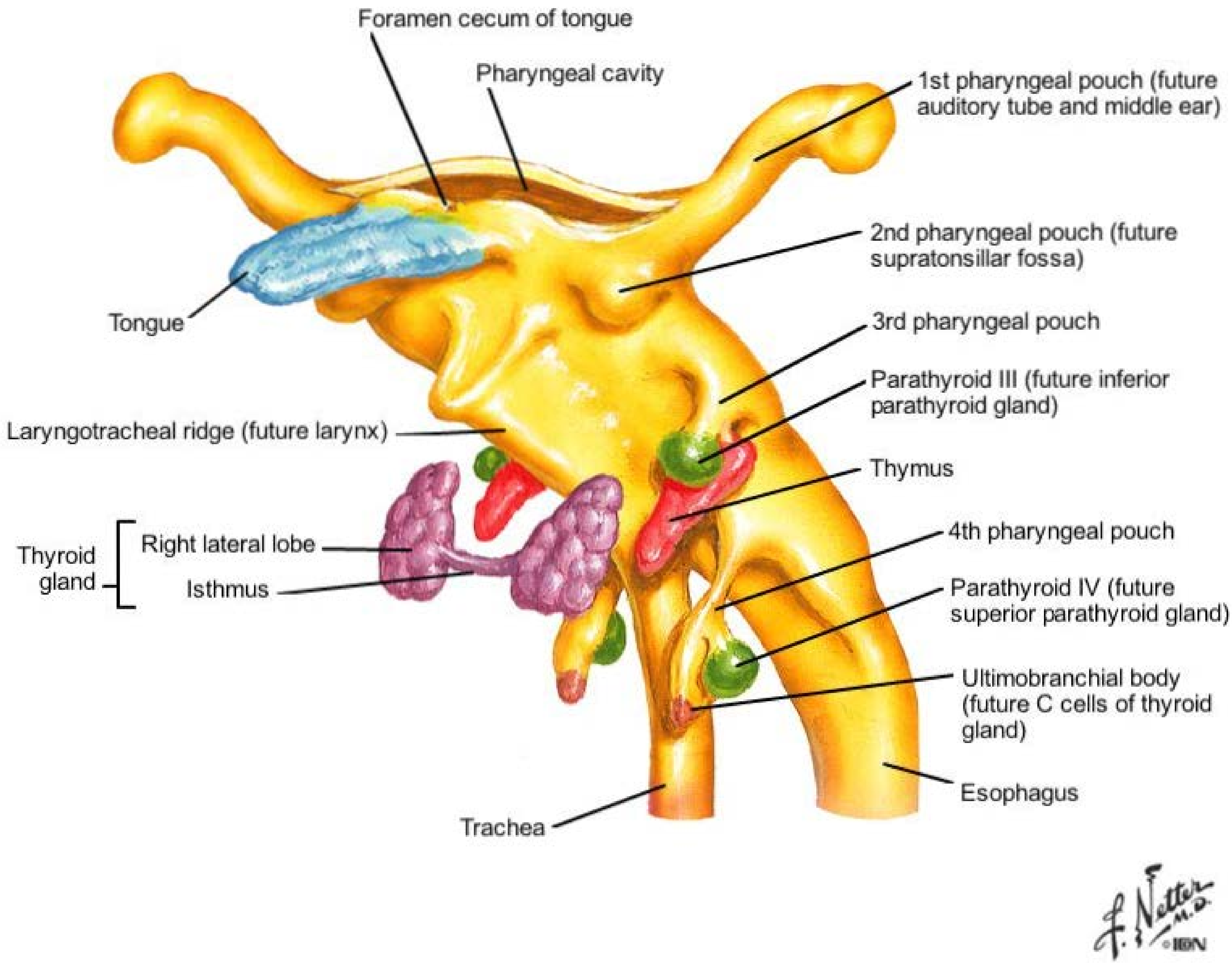


Fate of the Pharyngeal Pouches
Embryo at 4 to 5 weeks
Pharynx (ventral view)

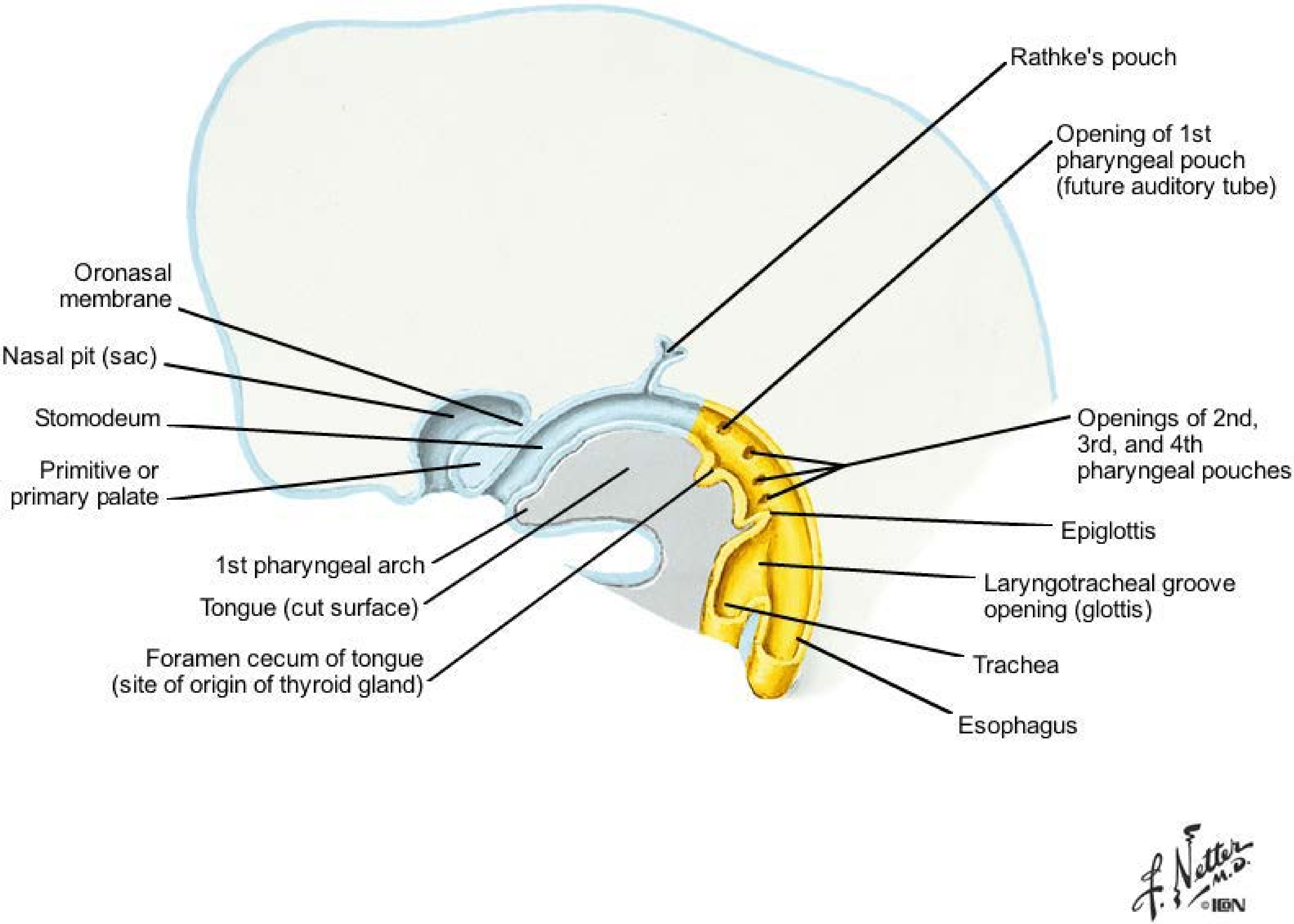


Fate of the Pharyngeal Pouches

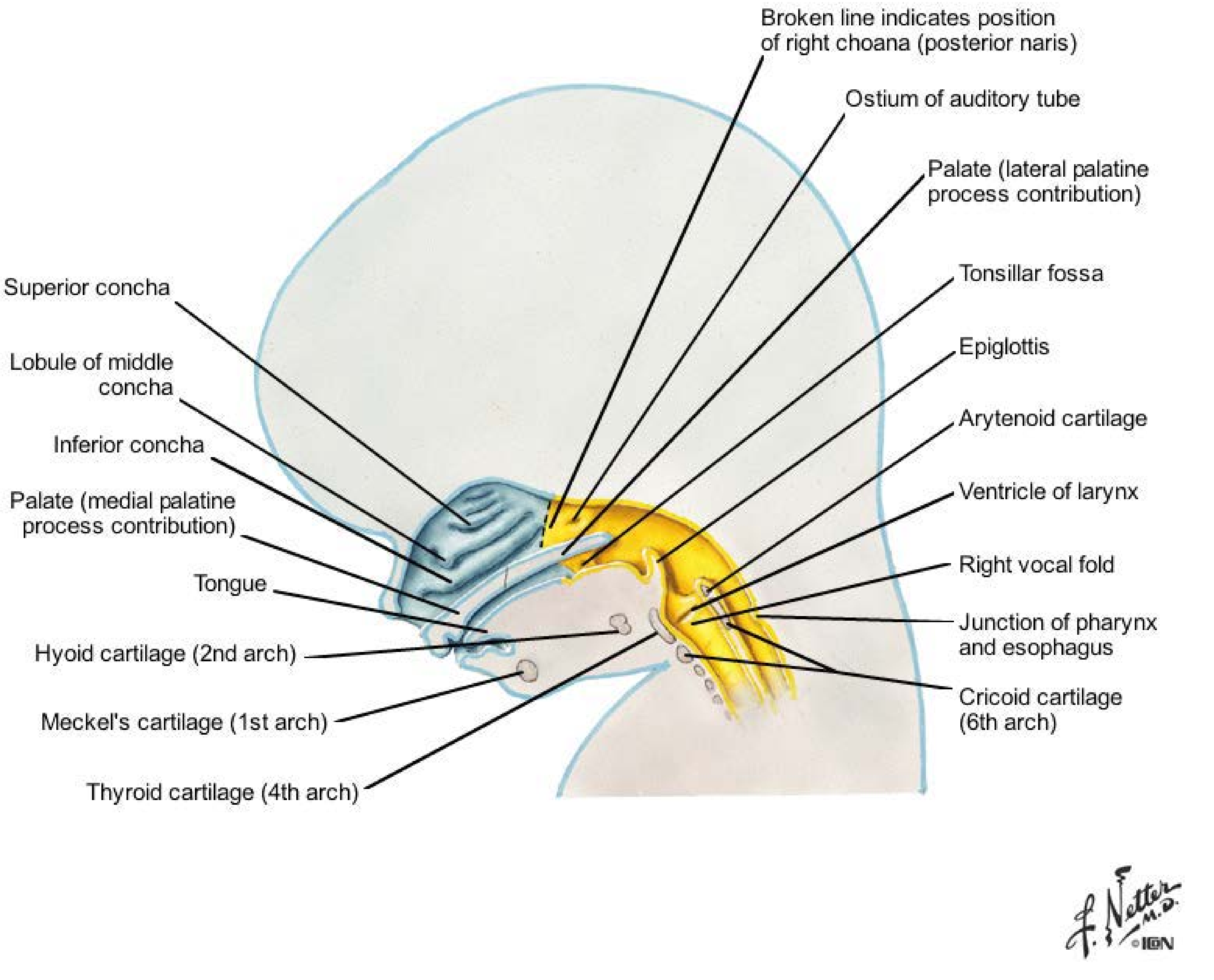
Embryo at 4 to 5 Weeks
Pharynx (anterior view of left side)



Midsagittal View of the Pharynx
Sagittal section at 5 to 6 weeks



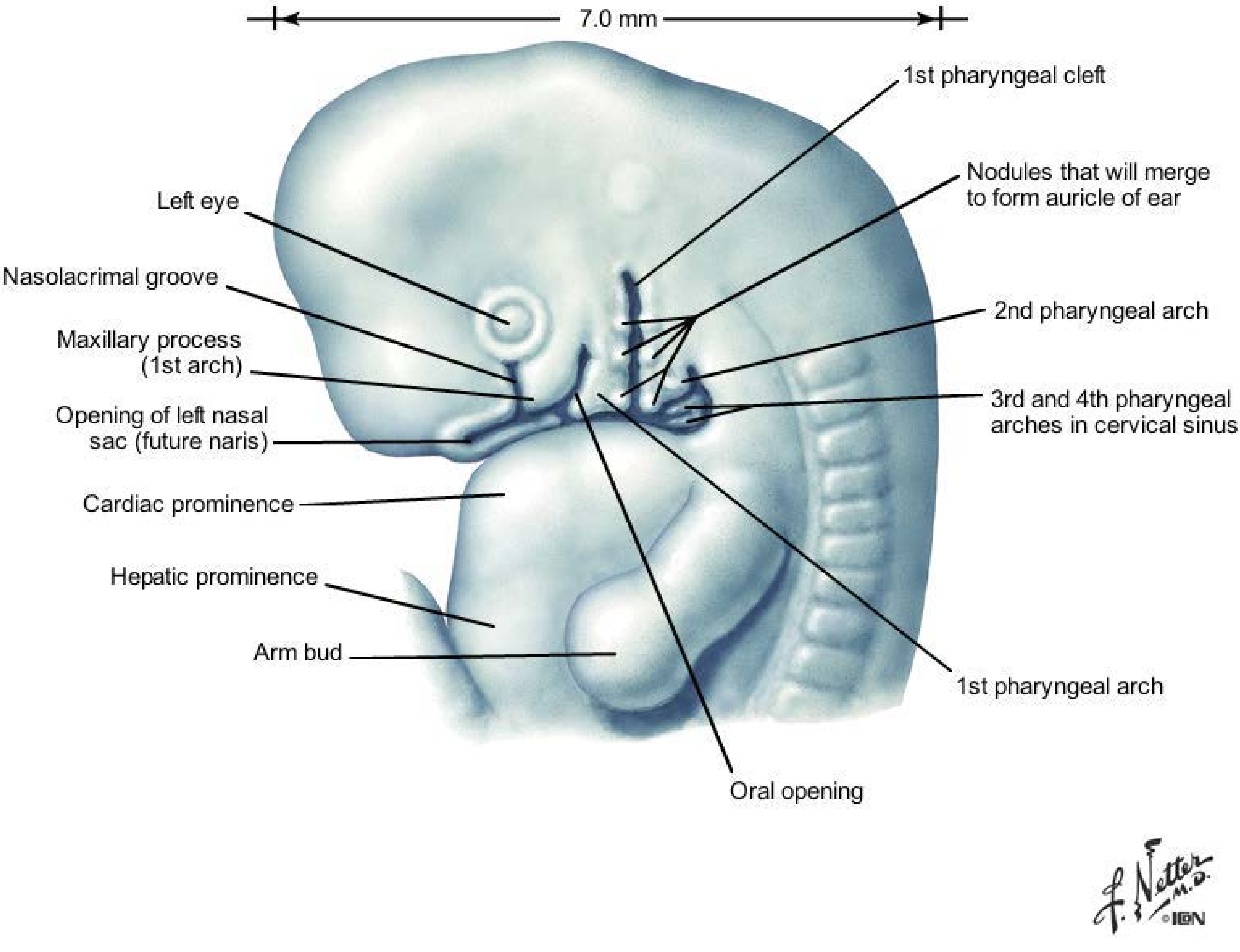
Midsagittal View of the Pharynx
Sagittal section at 8 to 10 weeks



Fate of the Pharyngeal Grooves

Lateral view at 6 to 7 weeks

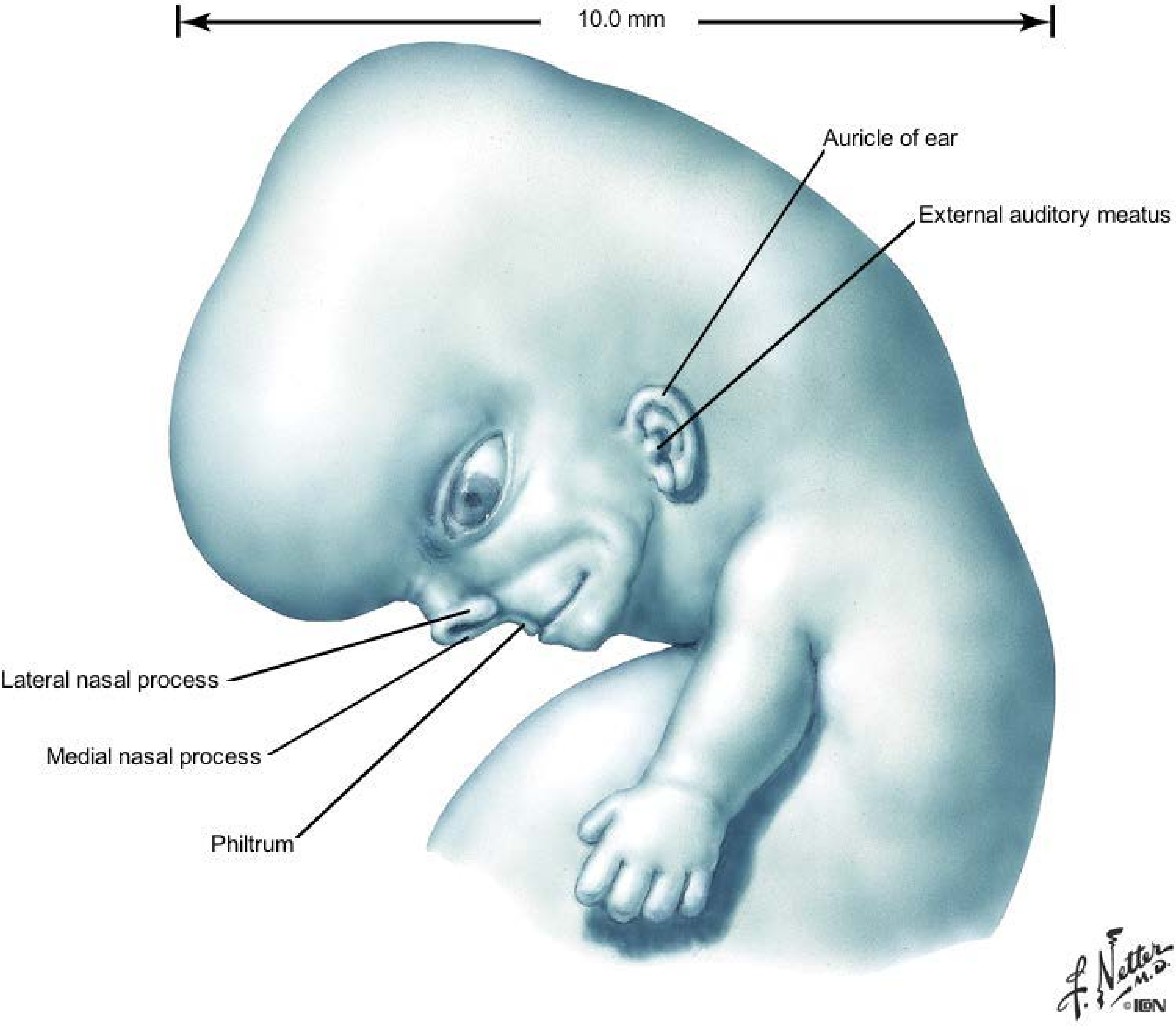
Embryo at 6 to 8 weeks



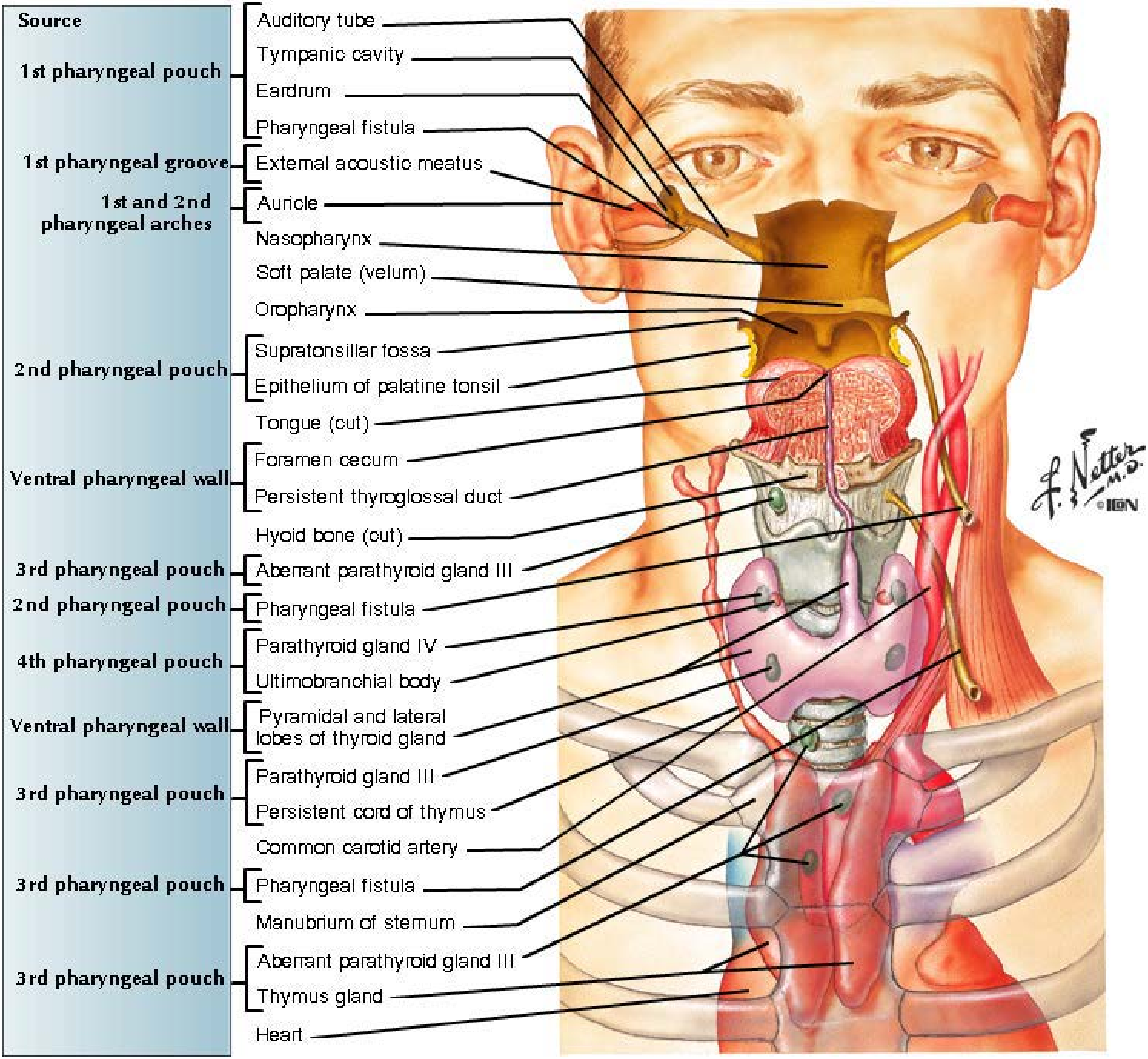
Fate of the Pharyngeal Grooves

Lateral view at 7 to 8 weeks

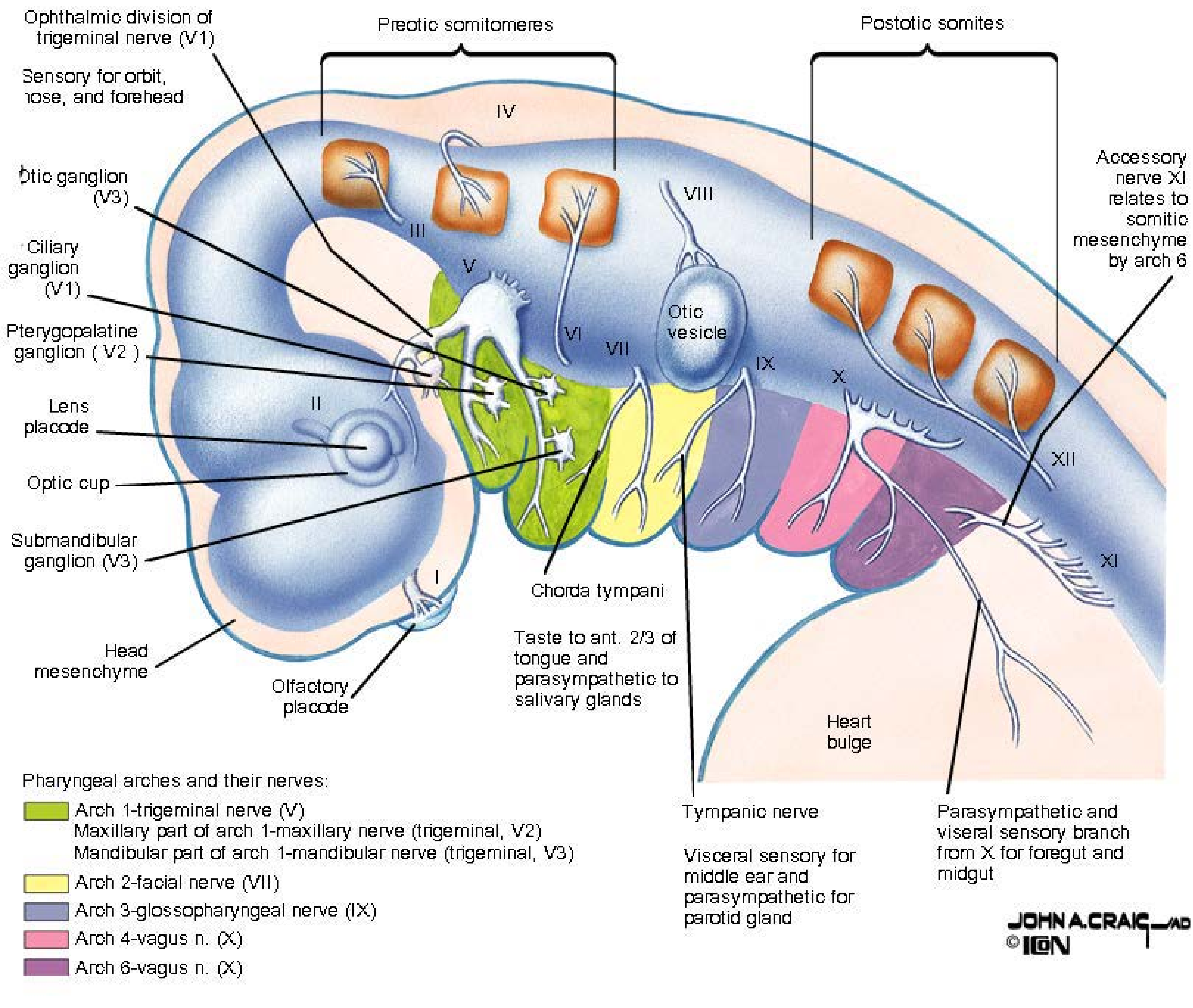
Embryo at 6 to 8 weeks



Pharyngeal Groove and Pouch Anomalies



Pharyngeal Arch Nerves

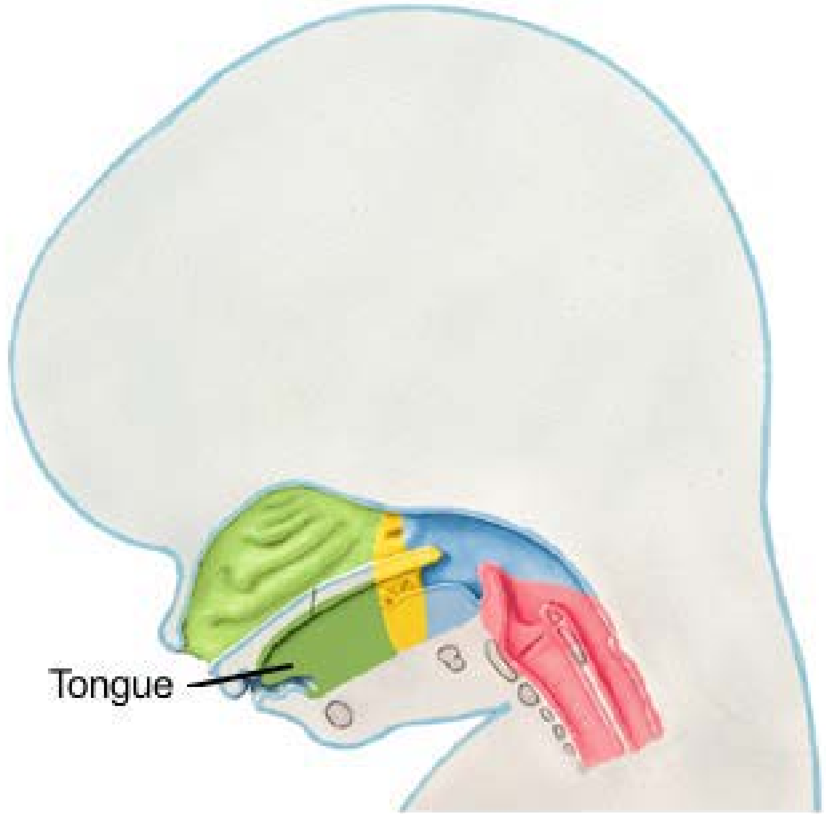


Sensory Innervation Territories

What the sensory nerve territories would be if the embryonic pattern of the pharyngeal arches were retained

Lateral view at 8 to 10 weeks

Sagittal section at 8 to 10 weeks

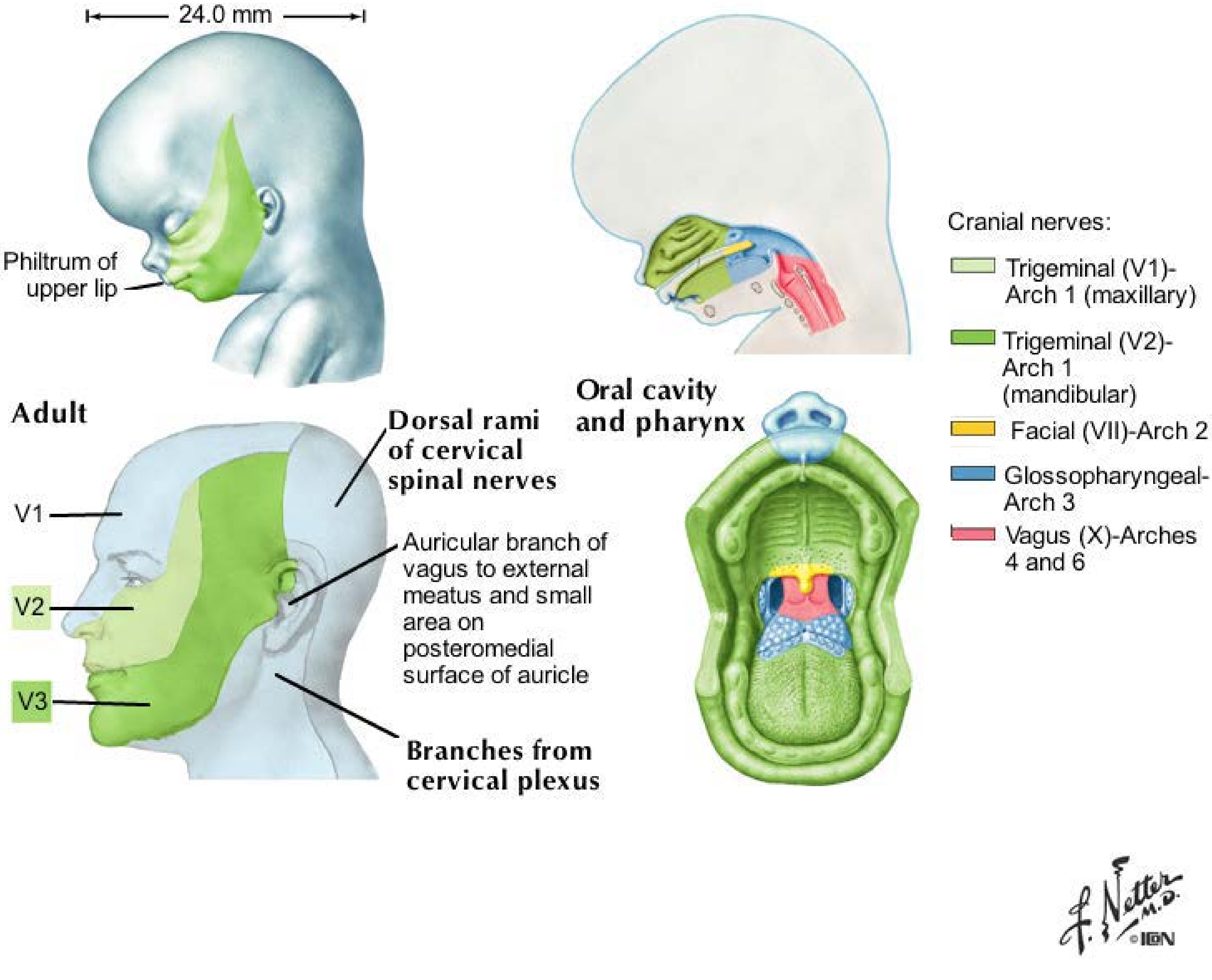


Cranial nerves:

- Trigeminal (V1)- Arch 1 (maxillary)
- Trigeminal (V2)-Arch 1 (mandibular)
- Facial (VII)-Arch 2
- Glossopharyngeal-Arch 3
- Vagus (X)-Arches 4 and 6

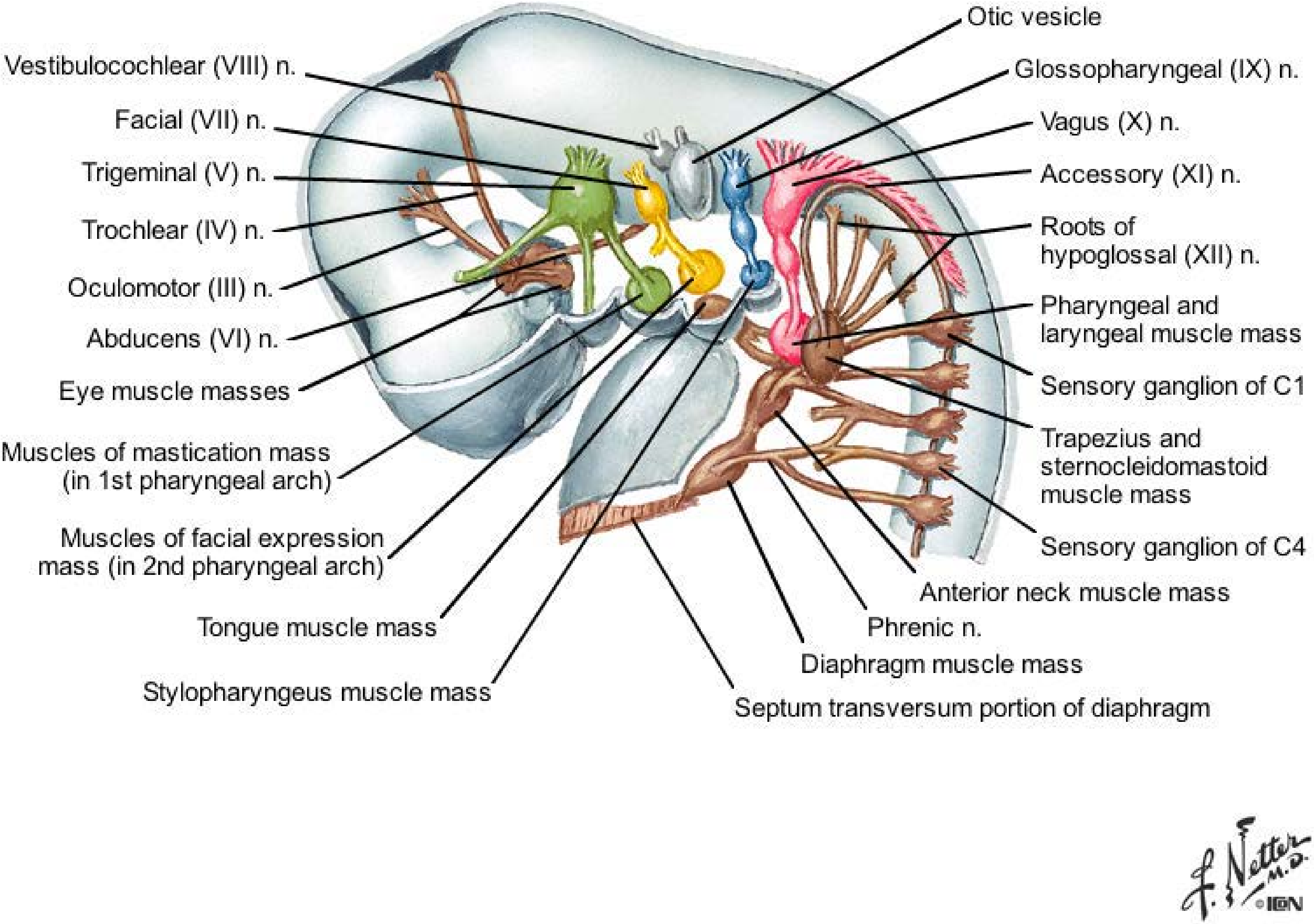
Sensory Innervation Territories

What the sensory territories actually are



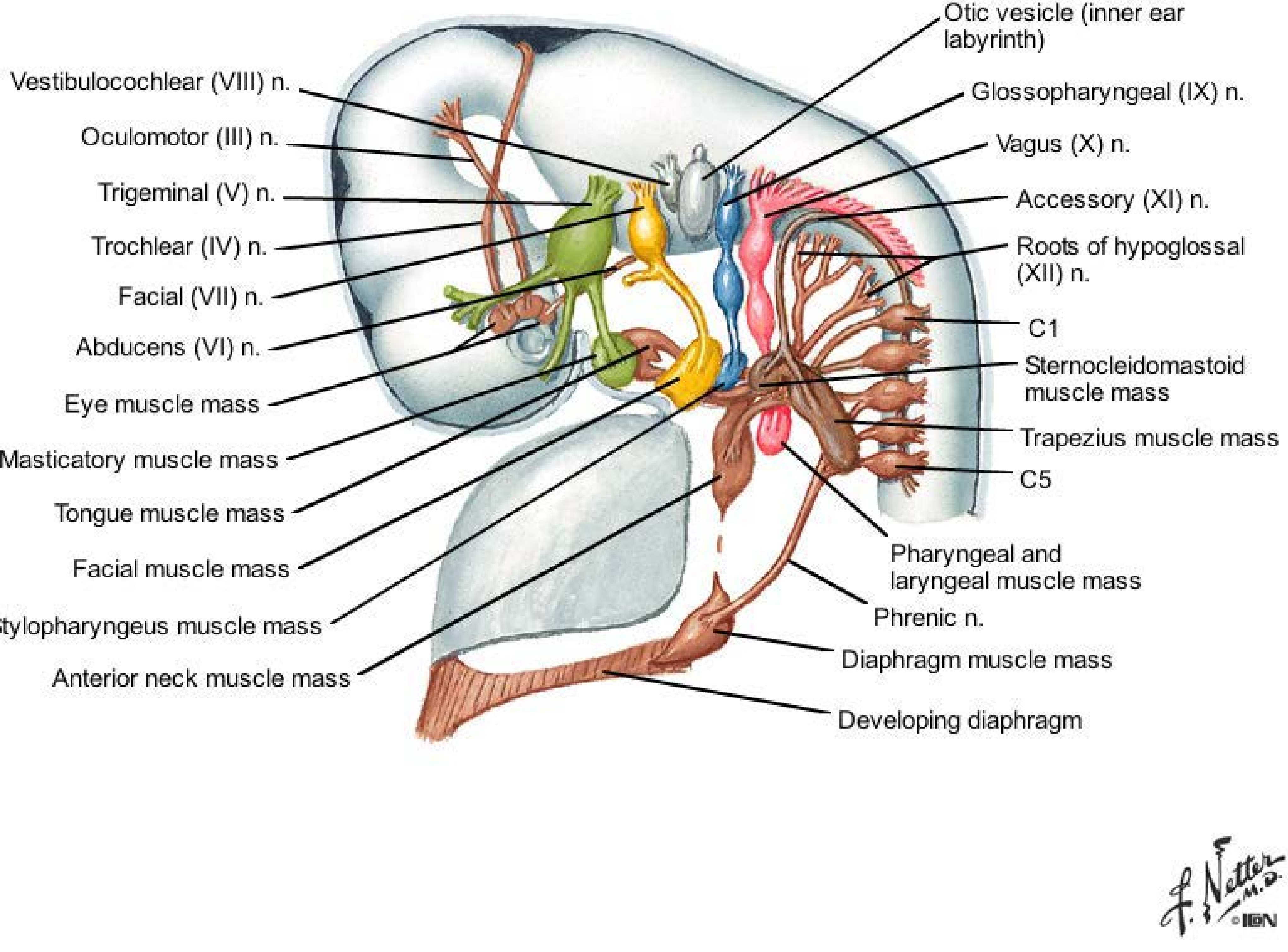
Early Development of Pharyngeal Arch Muscle

Origins and innervations of pharyngeal arch and somite myotome muscles at 5 weeks



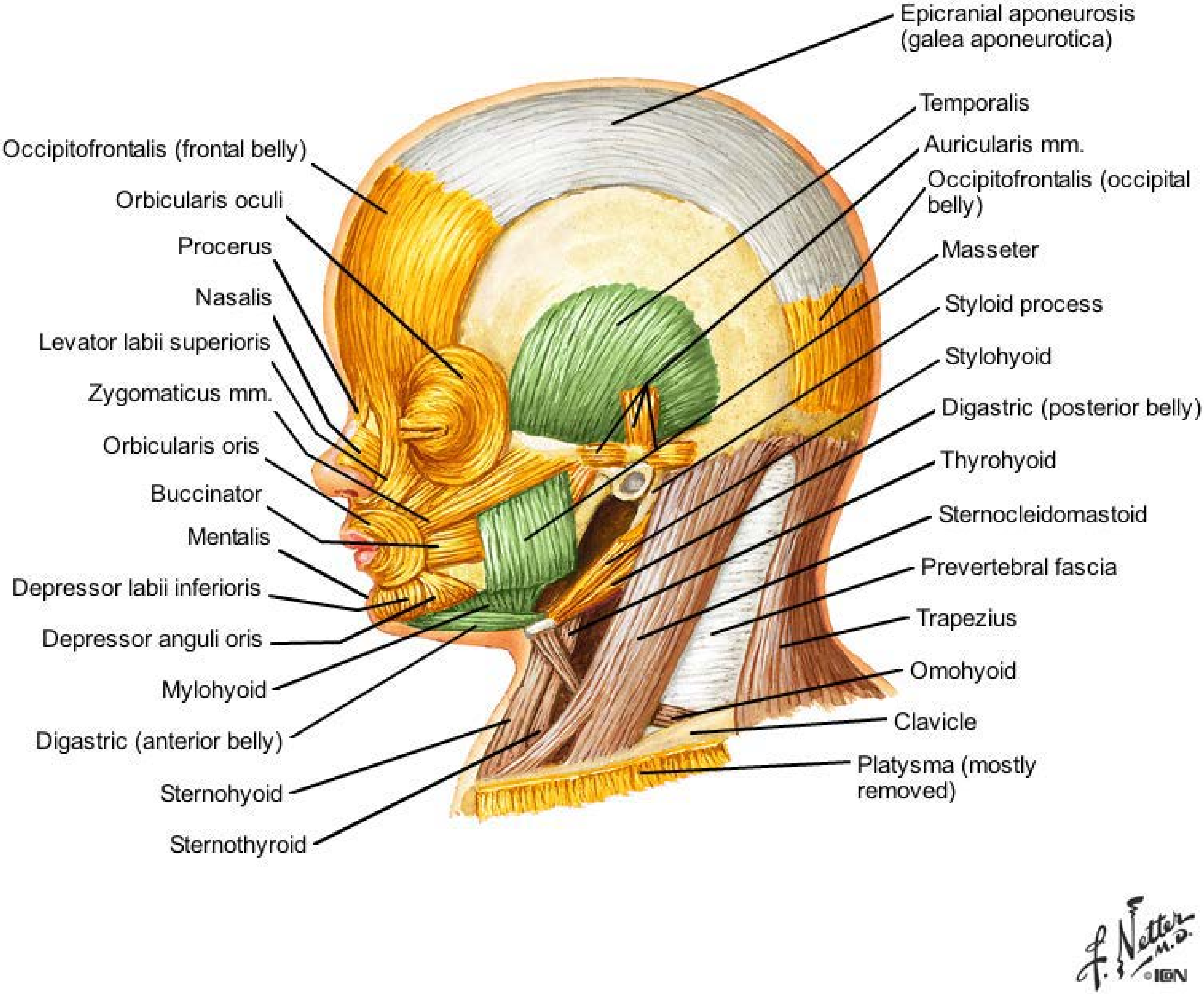
Early Development of Pharyngeal Arch Muscle

Origins and innervations of pharyngeal arch and somite myotome muscles at 6 weeks

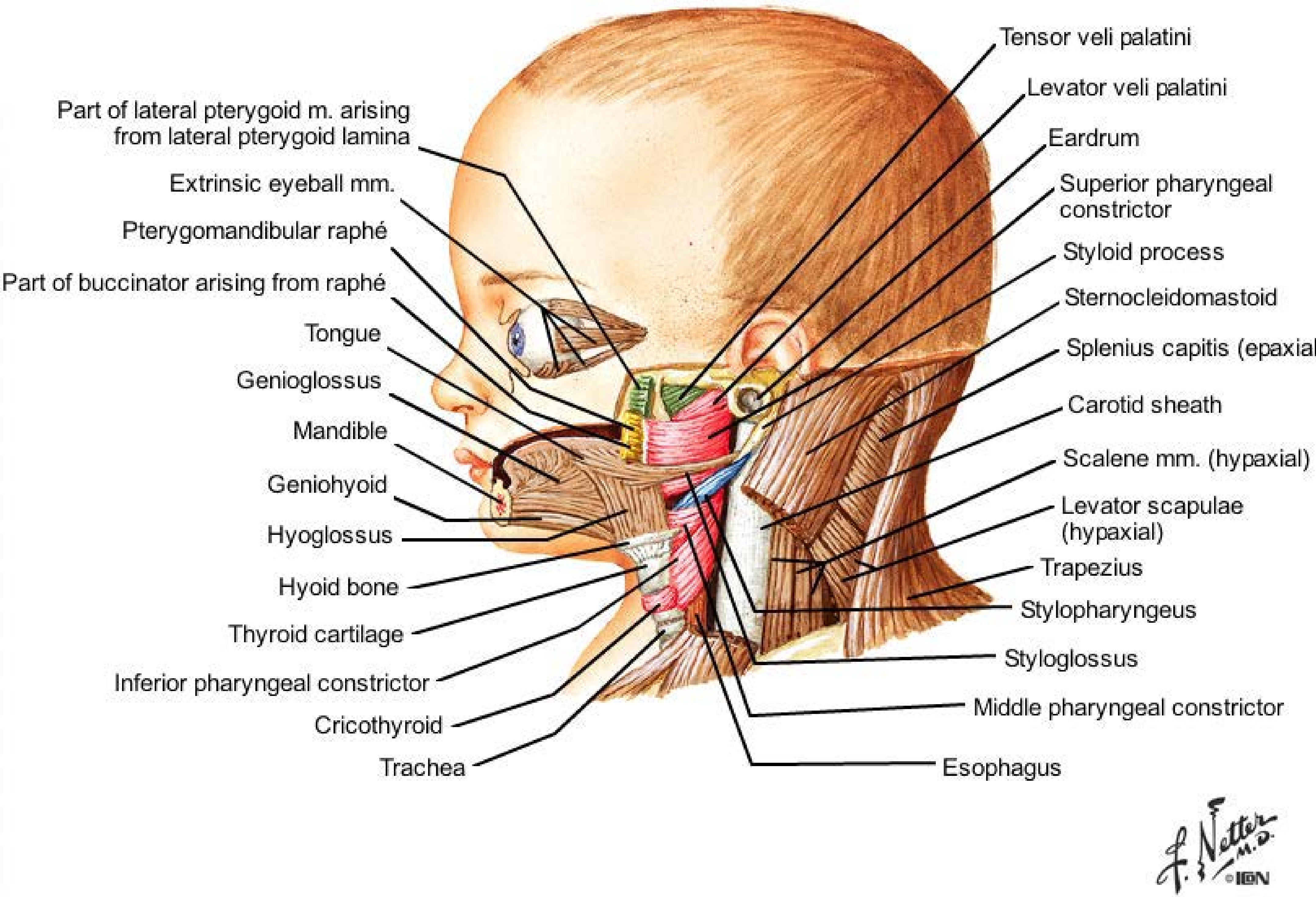


Later Development of Pharyngeal Arch Muscles

Superficial muscles

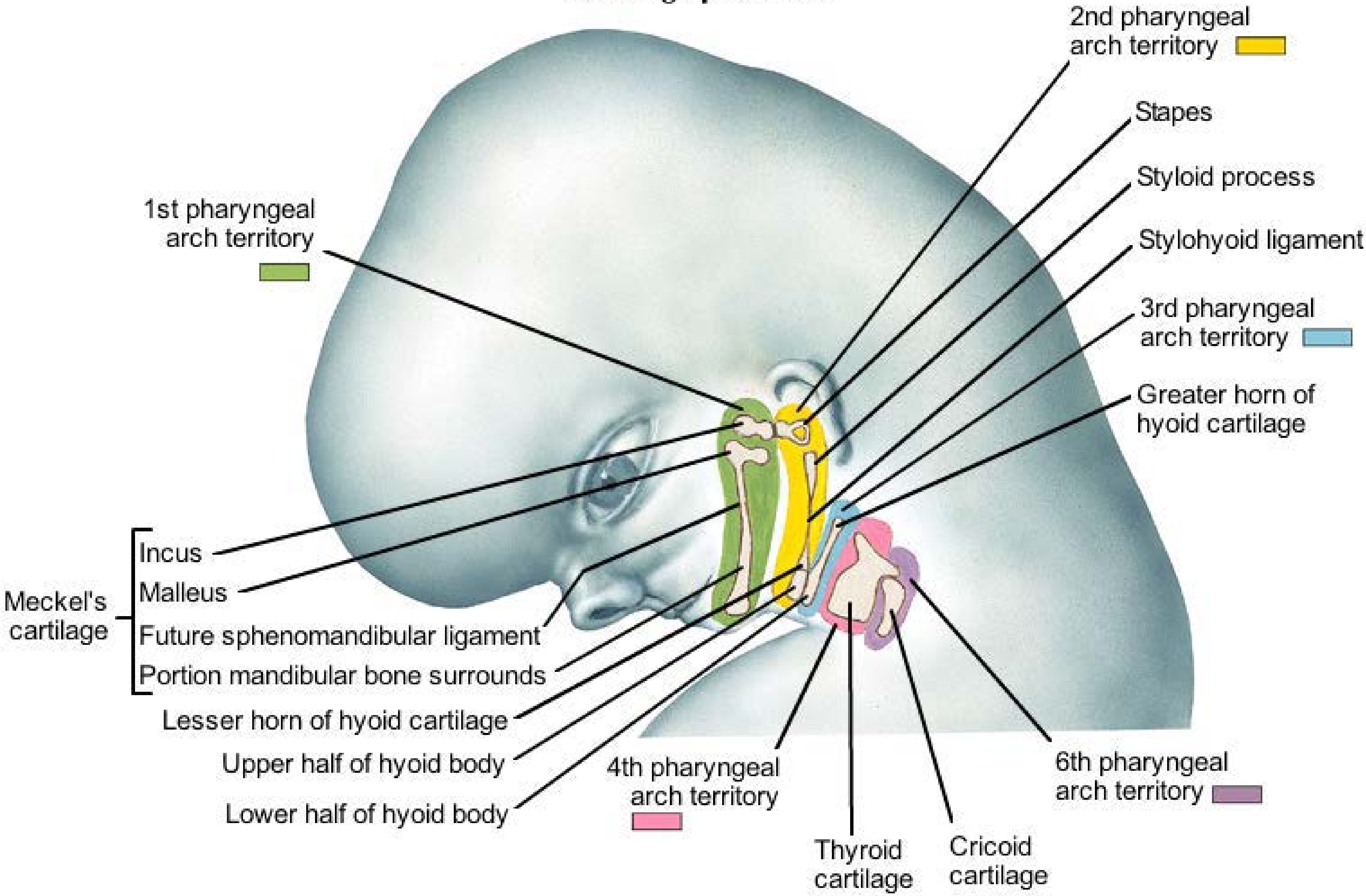


Later Development of Pharyngeal Arch Muscles
Deep muscles



Pharyngeal Arch Cartilages

Embryo at 7 to 8 weeks
Cartilage primordia



PHARYNGEAL ARCH BONES AND CARTILAGE

Arch #	Derivatives of Arch Cartilages
1	Malleus, incus, sphenomandibular ligament
2	Stapes, styloid process, stylohyoid ligament, upper half of hyoid
3	Lower half and greater horns of hyoid
4	Thyroid and epiglottic cartilages of larynx
6	Cricoid, arytenoid, and corniculate cartilages of larynx

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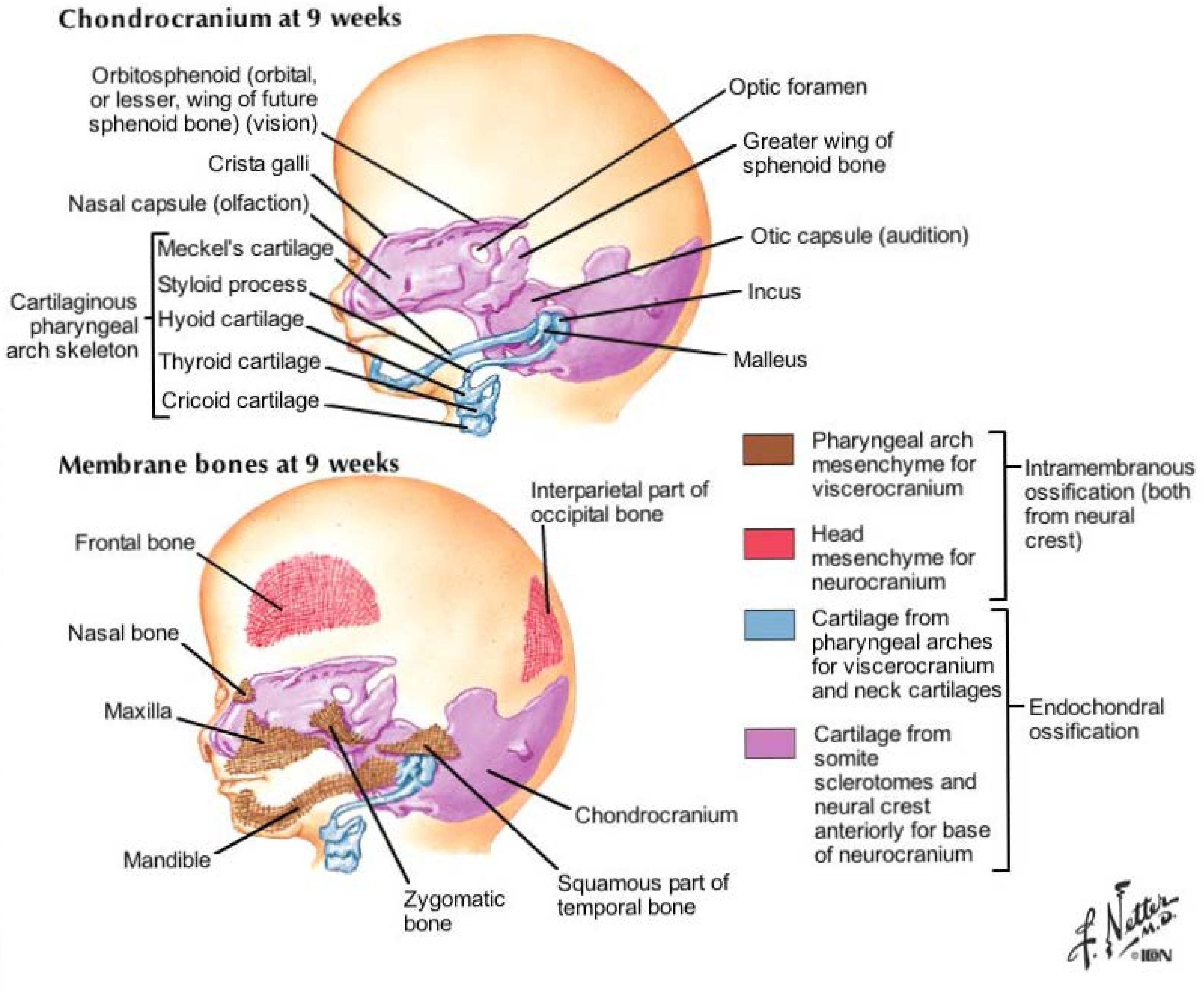
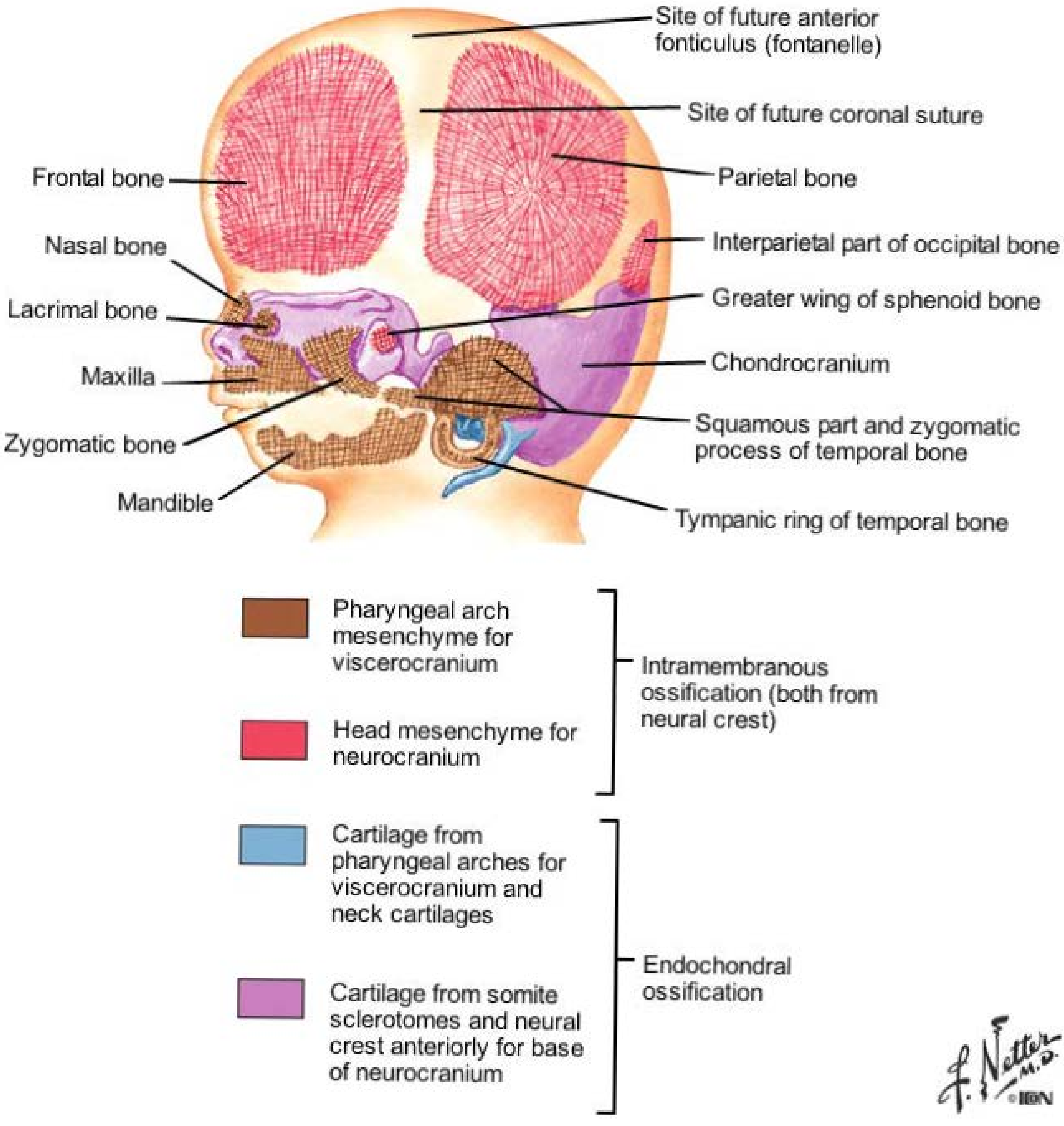
Ossification of the Skull

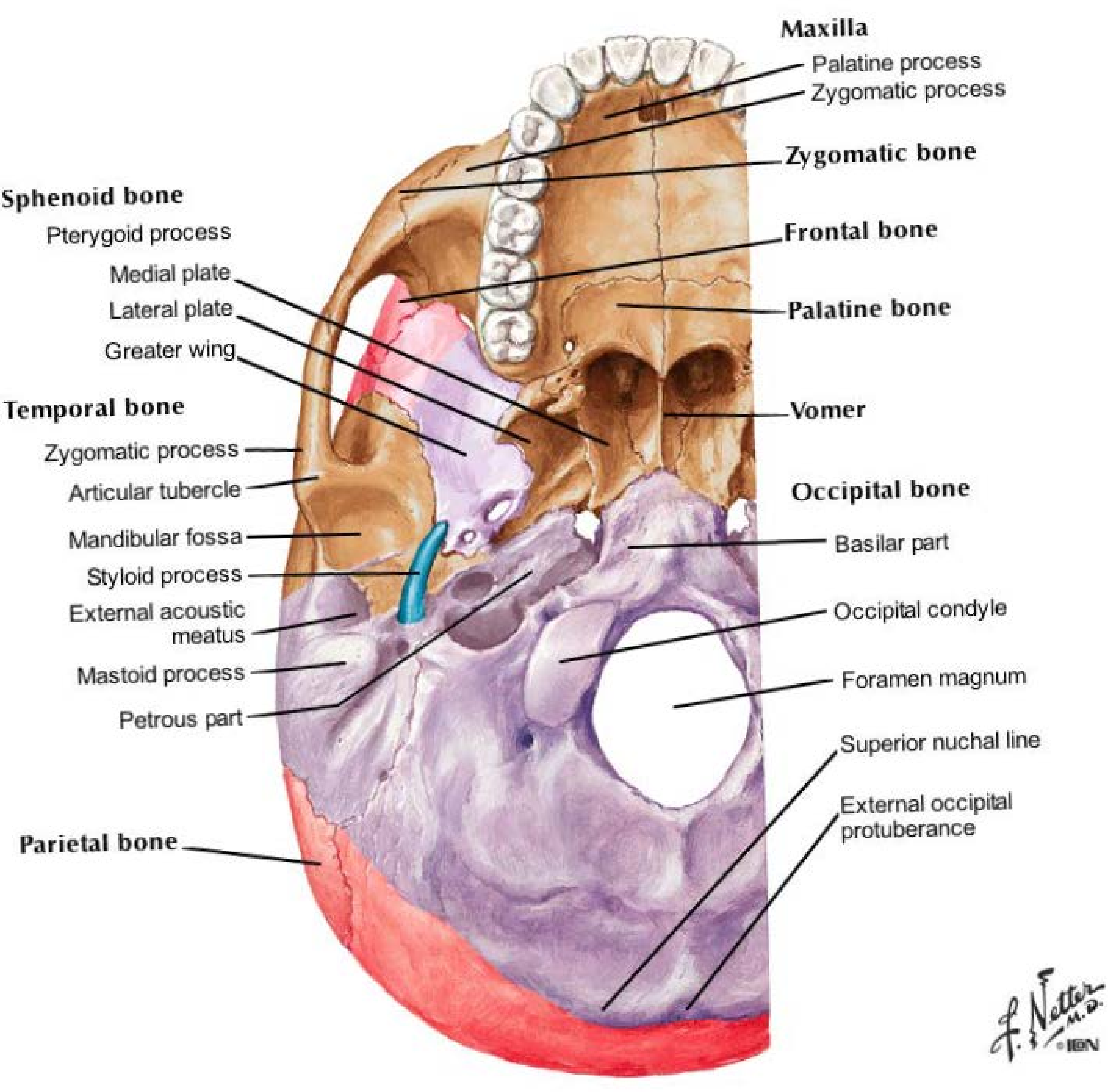


Ossification of the Skull

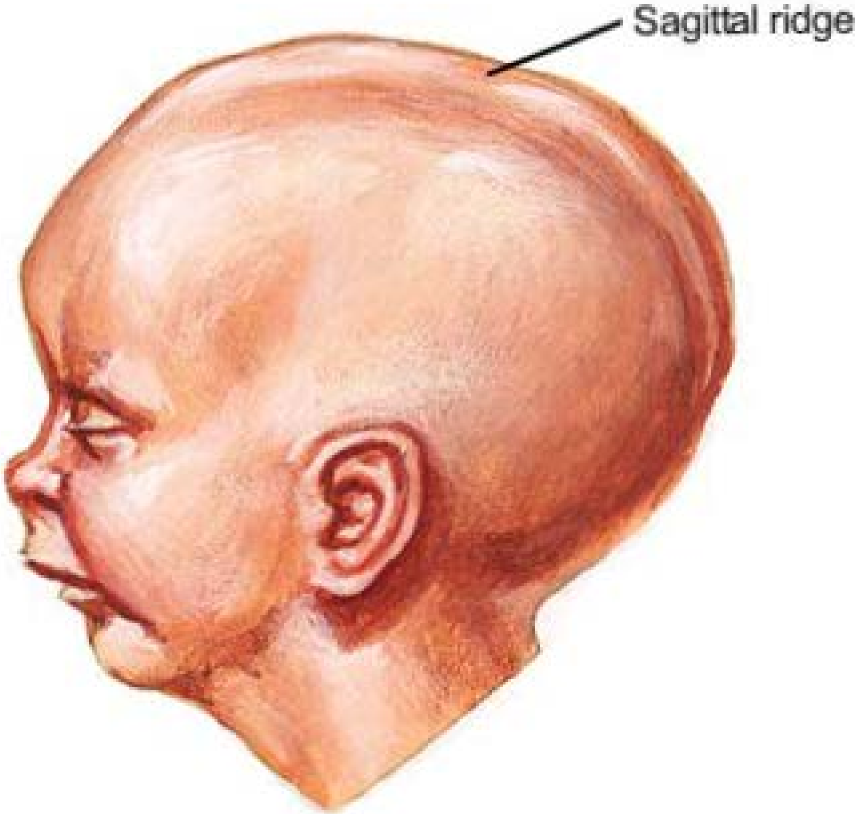
Membrane bones at 12 weeks



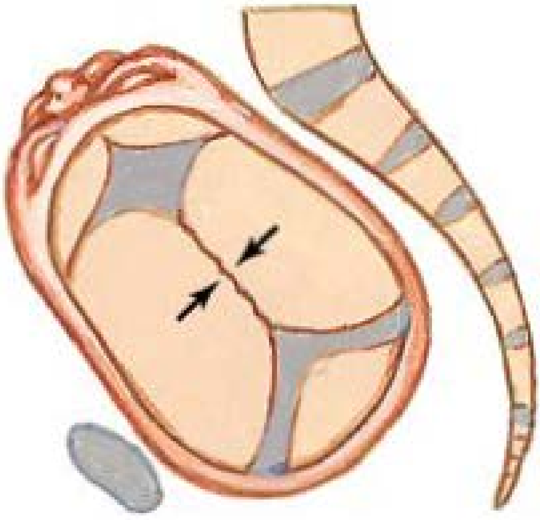
Ossification of the Scull



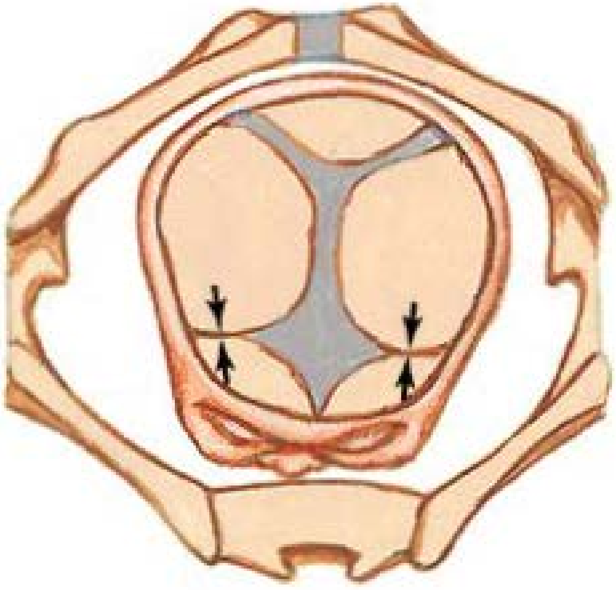
Premature Suture Closure



Scaphocephaly due to sagittal craniosynostosis



Limitation of growth of sagittal suture

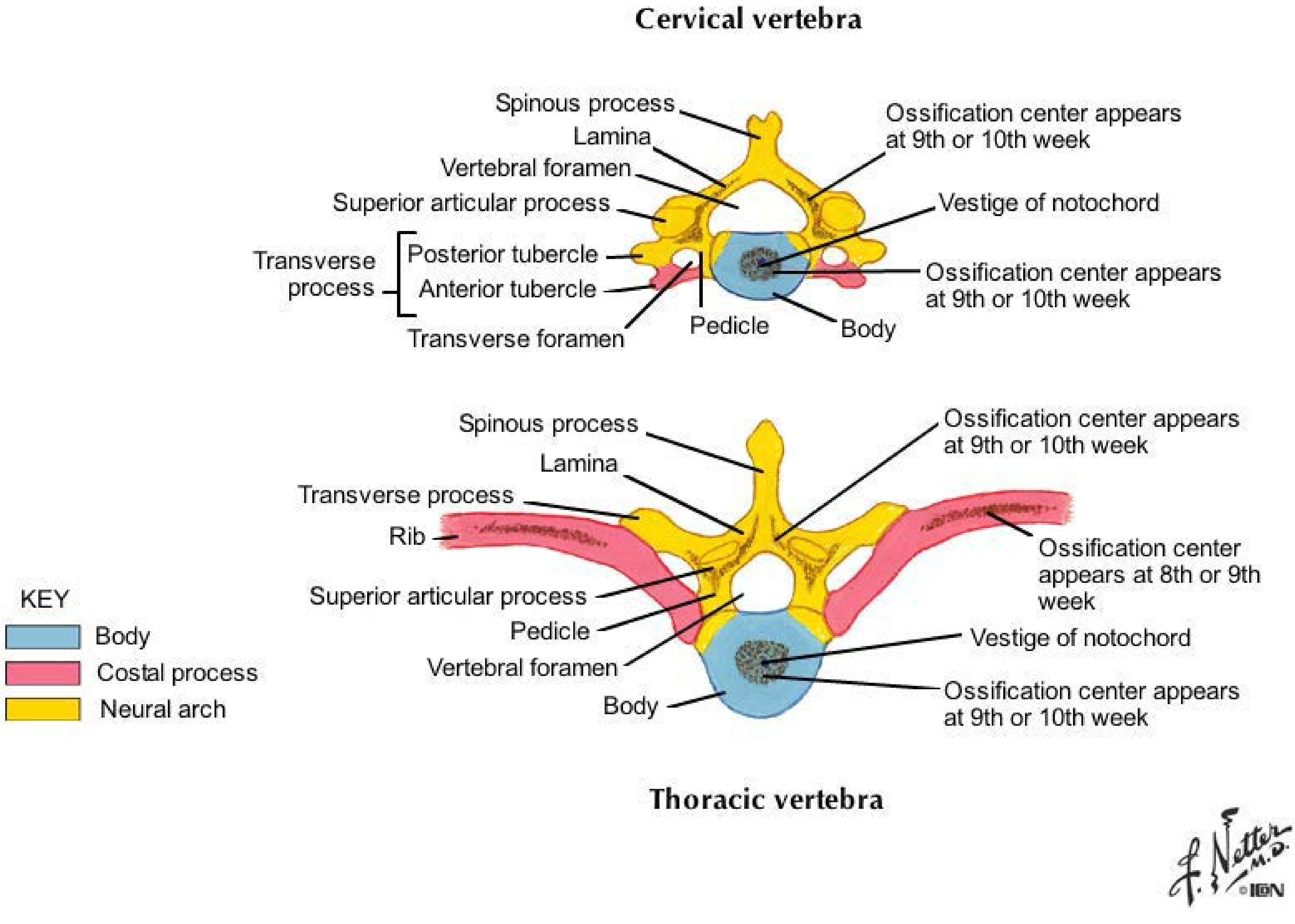


Limitation of growth of coronal sutures

Brachycephaly due to coronal craniosynostosis

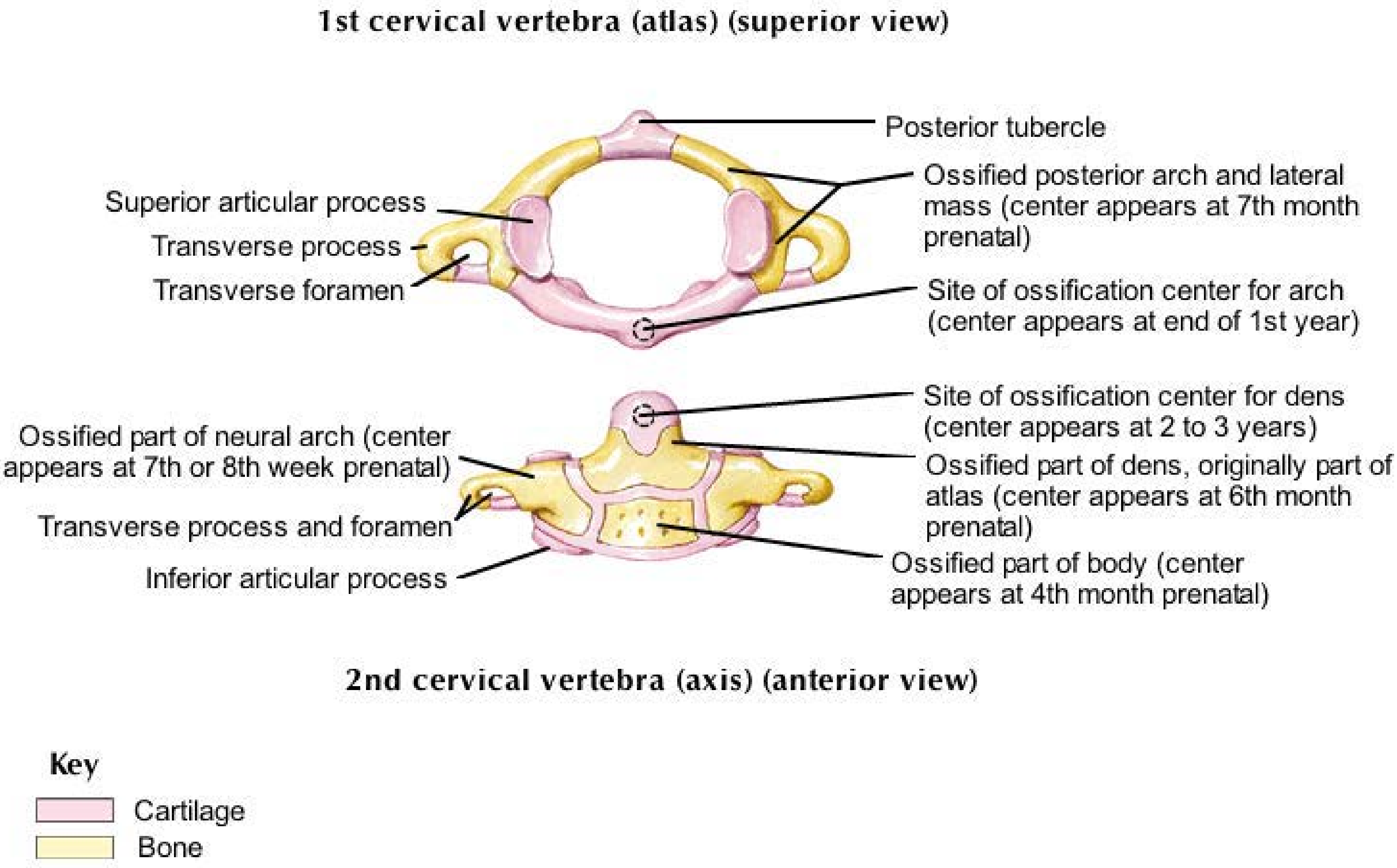
Cervical Ossification

Fate of body, costal process, and neural arch components of cervical and thoracic vertebra, with sites and time of appearance of ossification centers

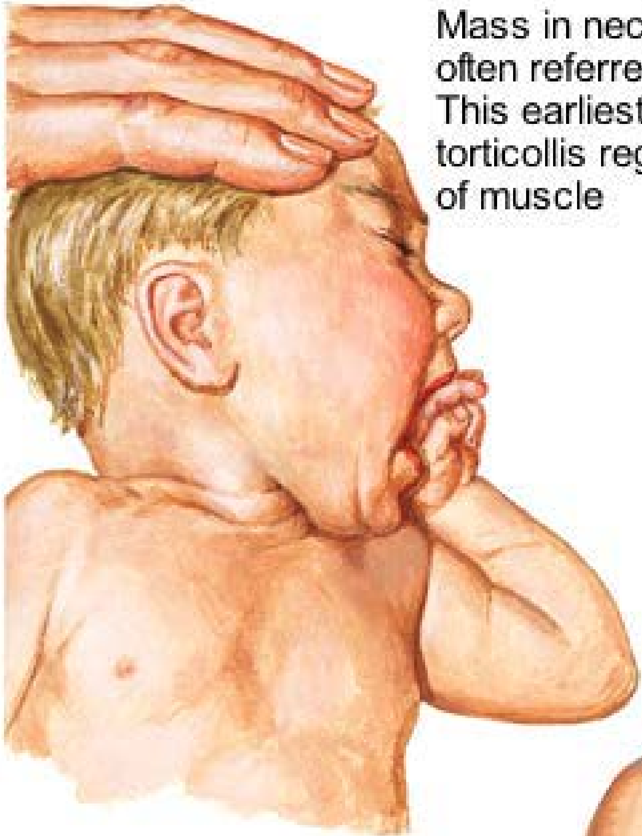


Cervical Ossification

First and second cervical vertebrae at birth

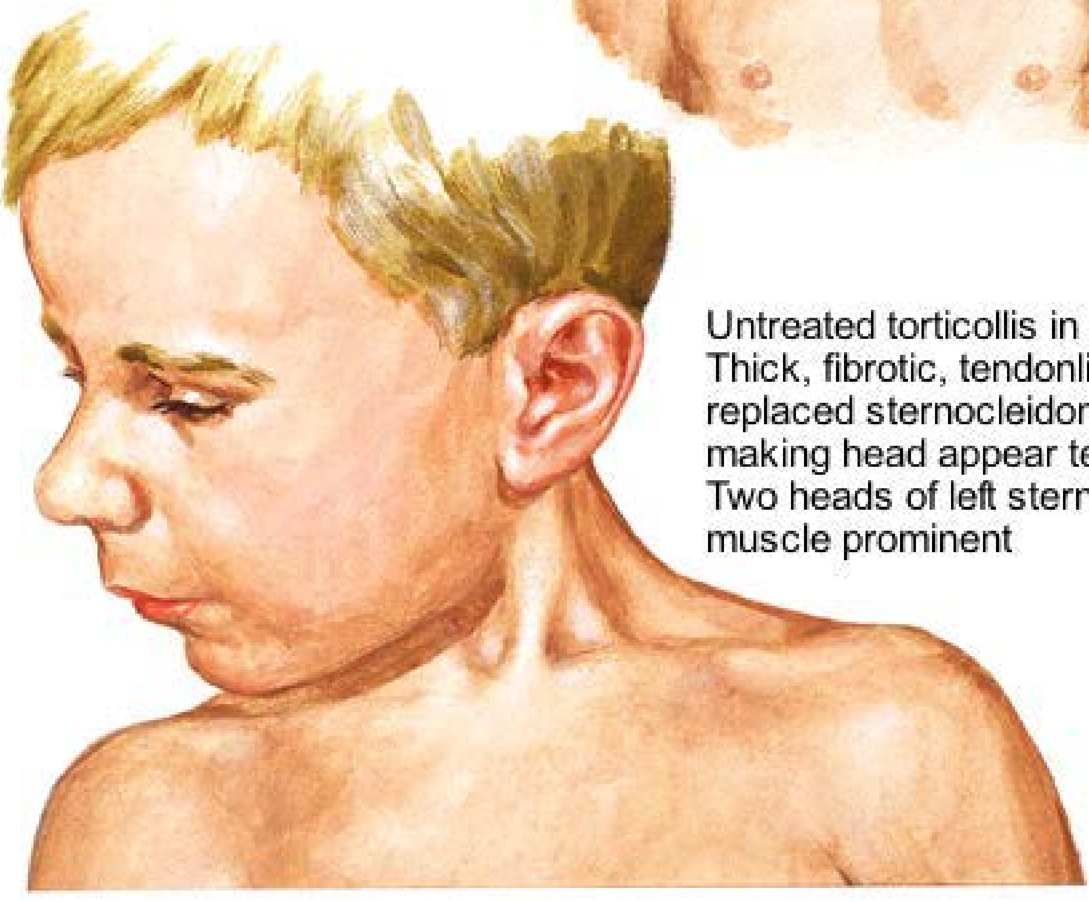


Torticollis



Mass in neck within sternocleidomastoid muscle often referred to as sternocleidomastoid tumor. This earliest manifestation of congenital muscular torticollis regresses, to be followed by contracture of muscle

Child with muscular torticollis. Head tilted to left with chin turned slightly to right because of contracture of left sternocleidomastoid muscle. Note facial symmetry (flattening of left side of face)



Untreated torticollis in 5-year-old boy. Thick, fibrotic, tendonlike bands have replaced sternocleidomastoid muscle, making head appear tethered to clavicle. Two heads of left sternocleidomastoid muscle prominent

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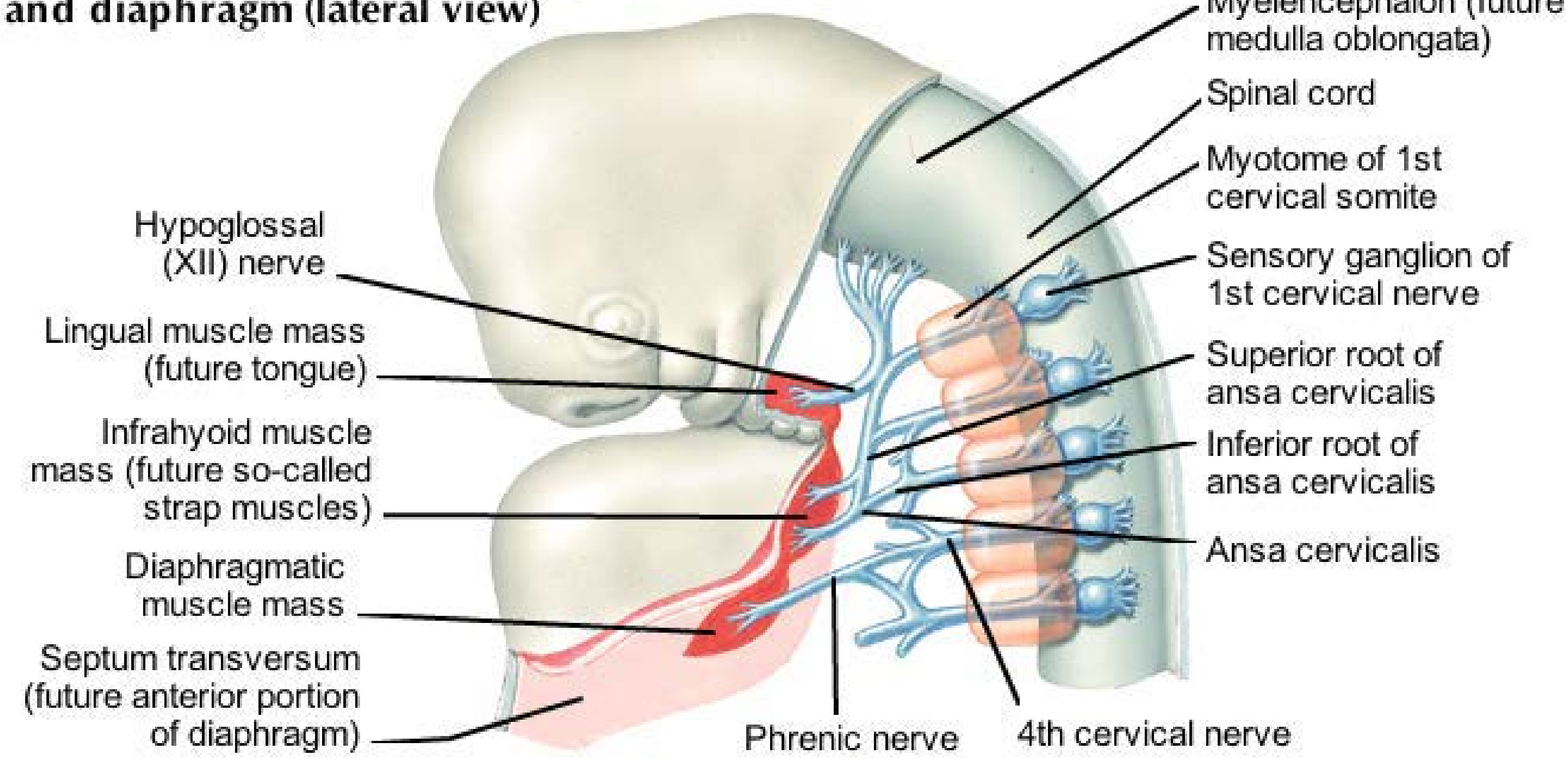
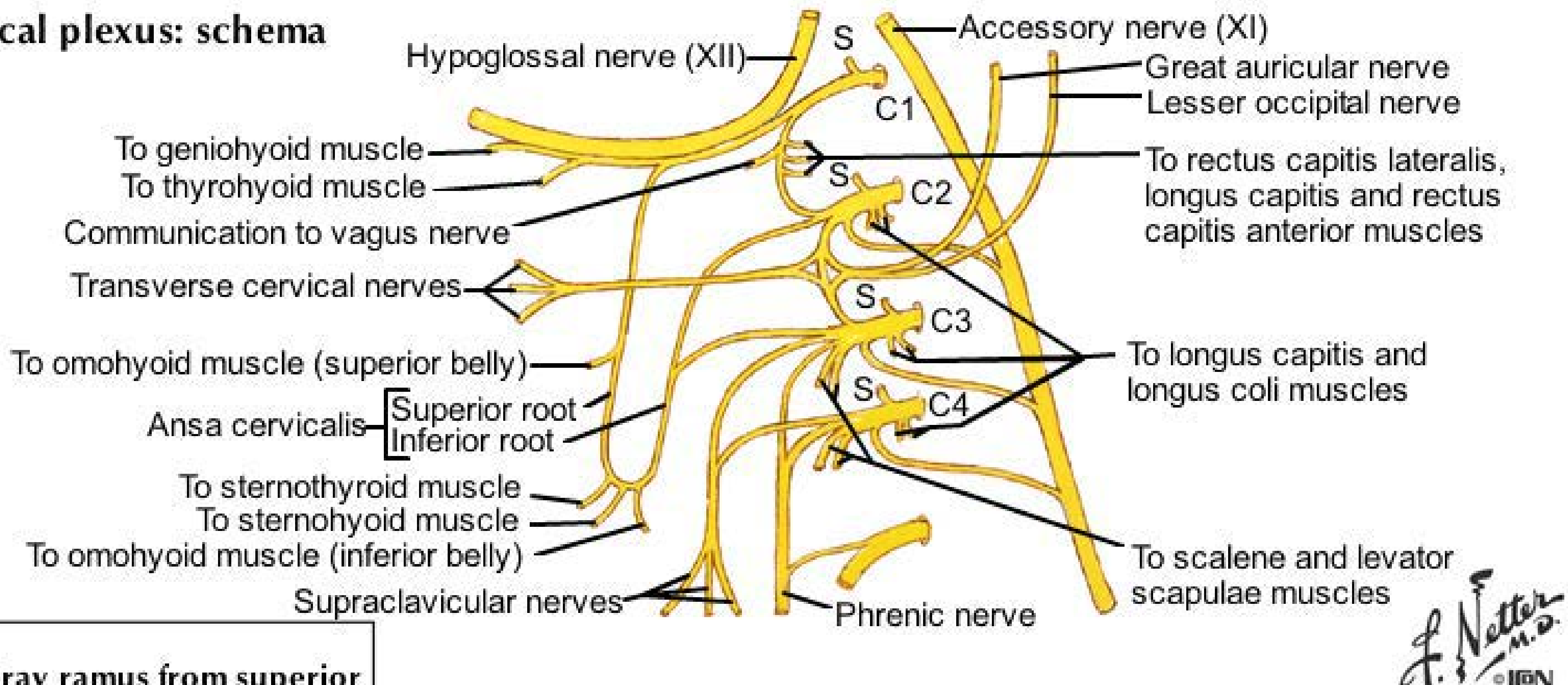
Cervical Plexus

The cervical plexus and hypoglossal nerve in a 5- to 6-week embryo

Innervation of muscle masses of tongue, neck, and diaphragm (lateral view)

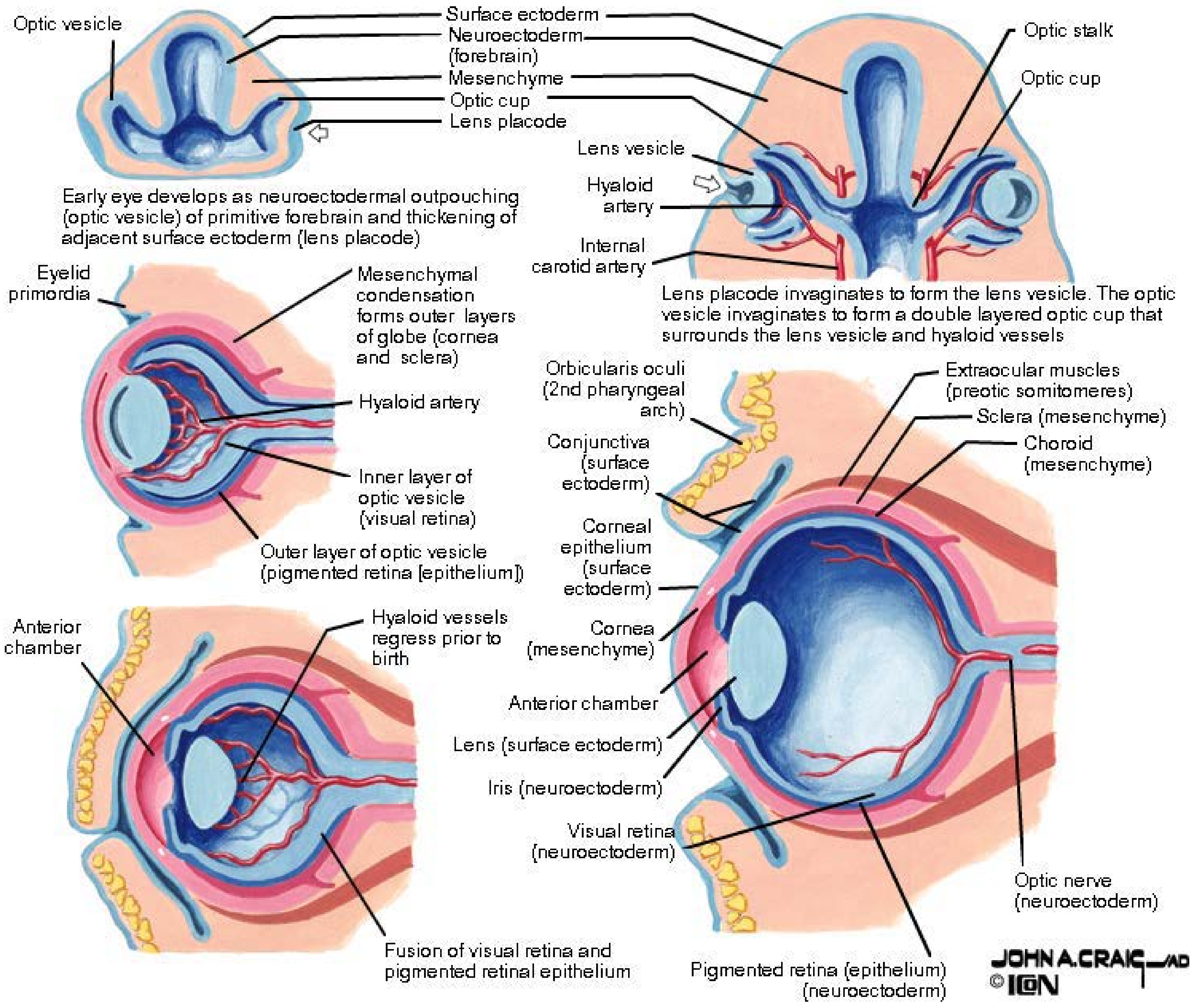


Cervical plexus: schema



Note:
S = 5 Gray ramus from superior cervical sympathetic ganglion

Orbit



Optic vesicle
Surface ectoderm
Neuroectoderm (forebrain)
Mesenchyme
Optic cup
Lens placode
Early eye develops as neuroectodermal outpouching (optic vesicle) of primitive forebrain and thickening of adjacent surface ectoderm (lens placode)
Optic stalk
Optic cup
Lens vesicle
Hyaloid artery
Internal carotid artery
Lens placode invaginates to form the lens vesicle. The optic vesicle invaginates to form a double layered optic cup that surrounds the lens vesicle and hyaloid vessels
Eyelid primordia
Mesenchymal condensation forms outer layers of globe (cornea and sclera)
Hyaloid artery
Inner layer of optic vesicle (visual retina)
Outer layer of optic vesicle (pigmented retina [epithelium])
Orbicularis oculi (2nd pharyngeal arch)
Extraocular muscles (preotic somitomeres)
Sclera (mesenchyme)
Choroid (mesenchyme)
Conjunctiva (surface ectoderm)
Corneal epithelium (surface ectoderm)
Cornea (mesenchyme)
Anterior chamber
Lens (surface ectoderm)
Iris (neuroectoderm)
Visual retina (neuroectoderm)
Optic nerve (neuroectoderm)
Pigmented retina (epithelium) (neuroectoderm)
Anterior chamber
Hyaloid vessels regress prior to birth
Fusion of visual retina and pigmented retinal epithelium
JOHN A.CRAIG_MD
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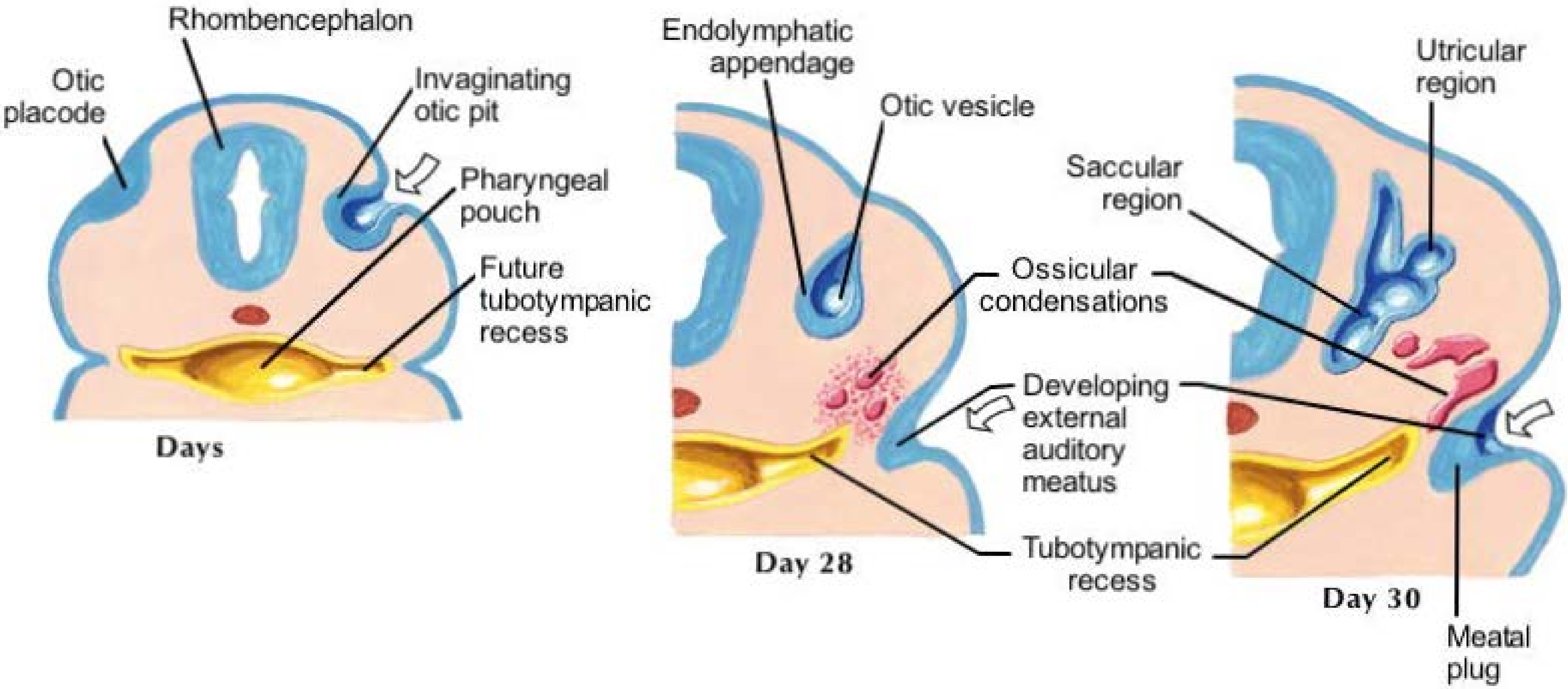
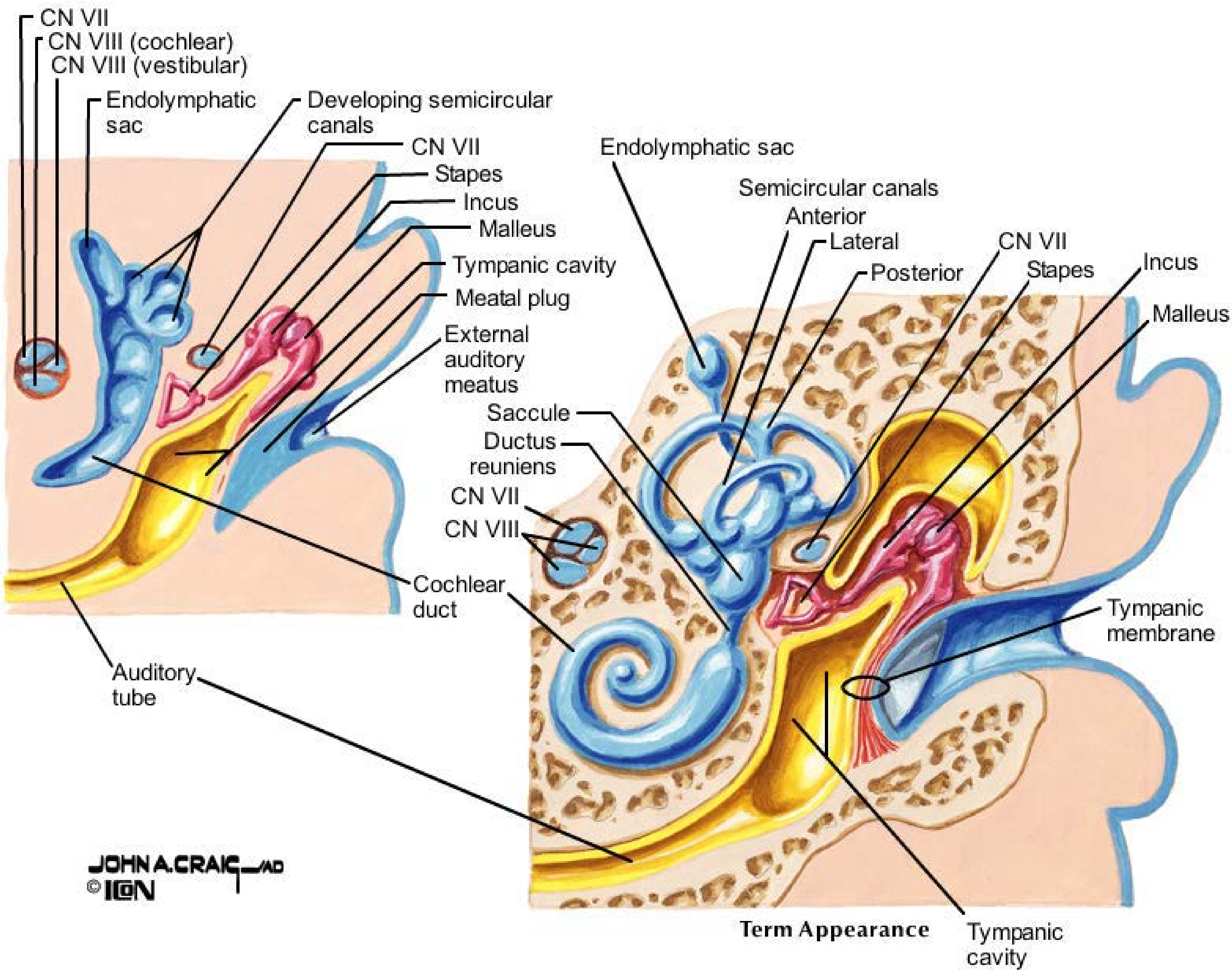
Ear Development



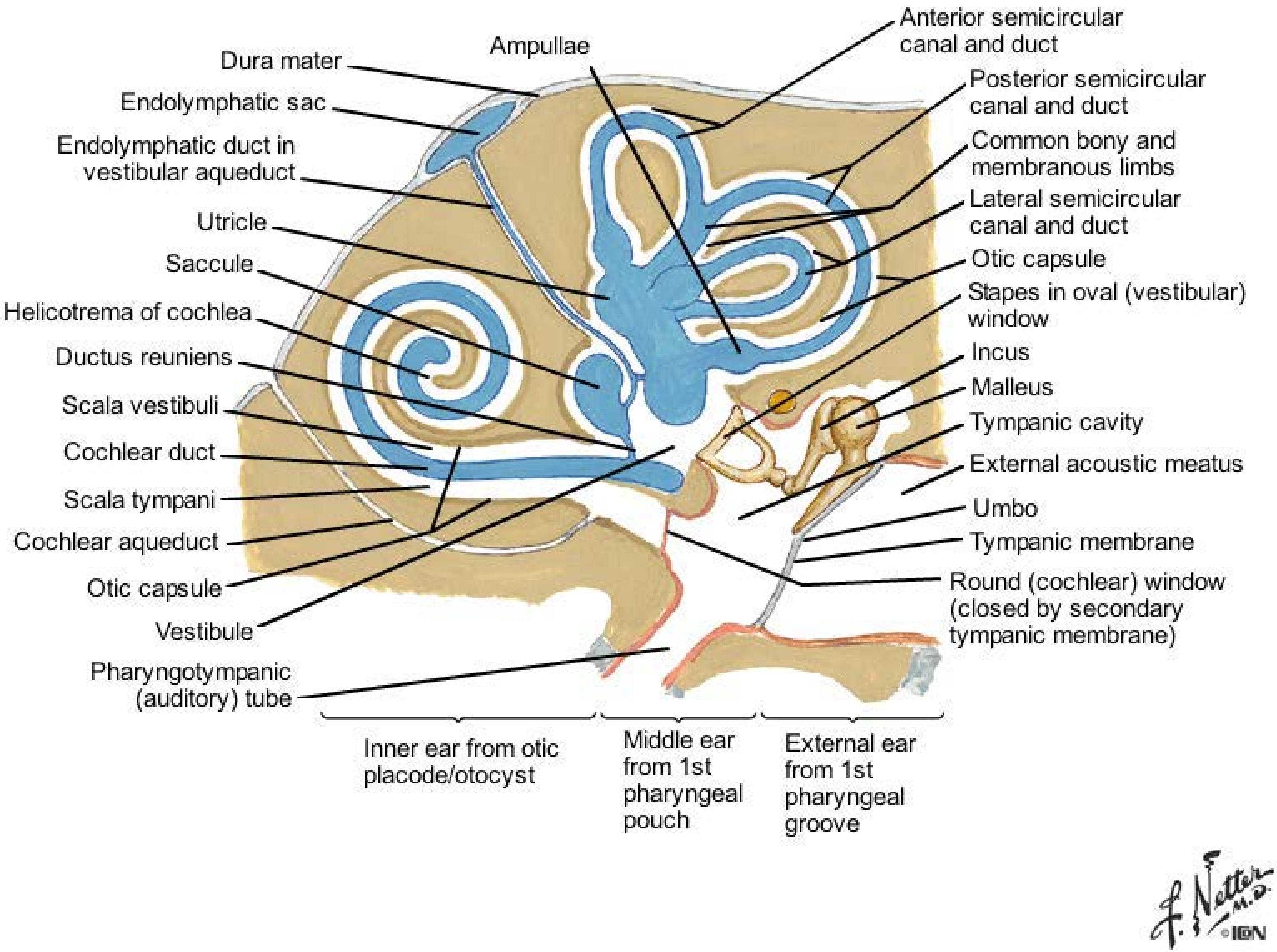
Ear Development



Term Appearance

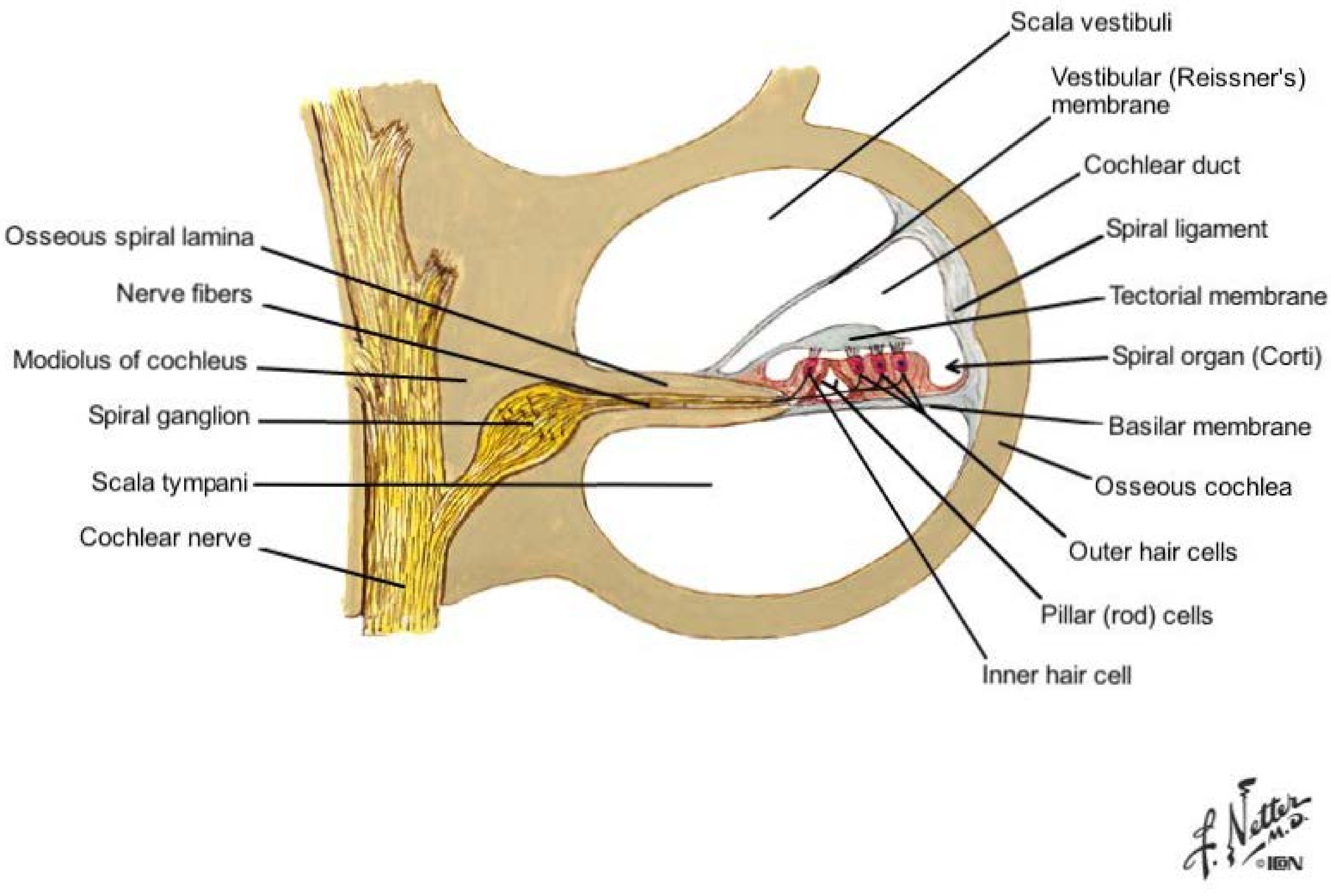
Adult Ear Organization

Bony and membranous labyrinths: schema



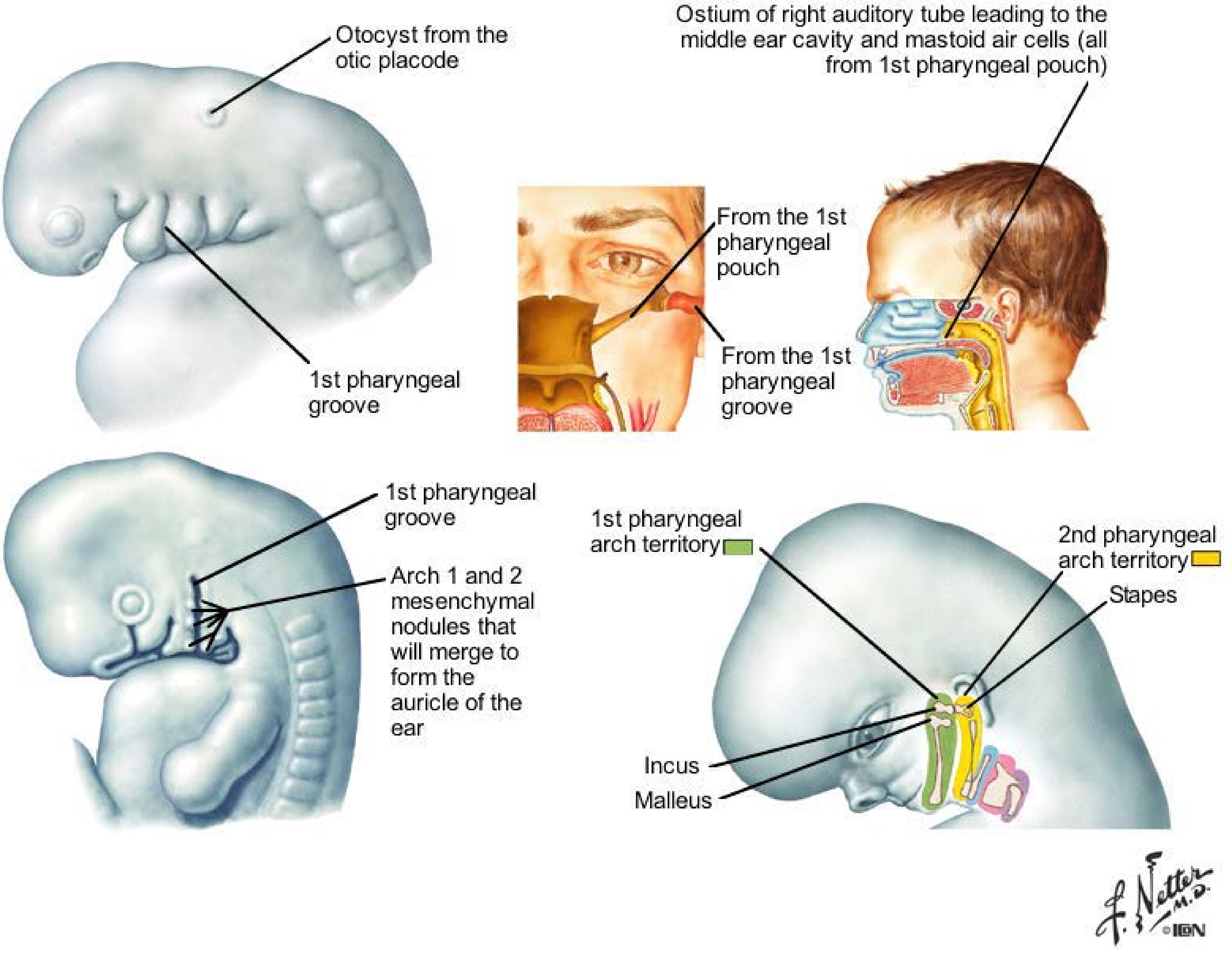
Adult Ear Organization

Section through turn of cochlea

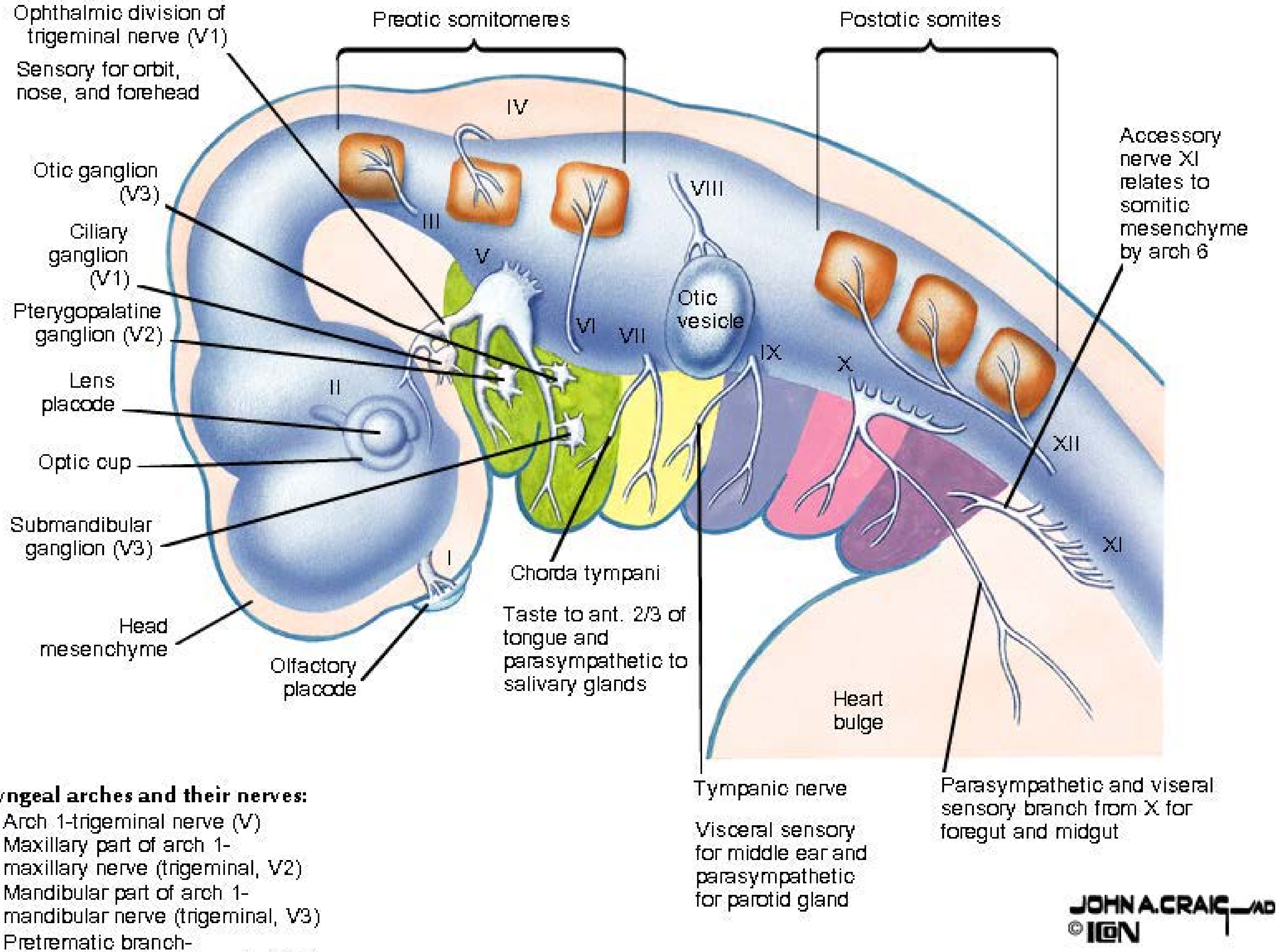


Summary of Ear Development

Primordia of the outer, middle, and inner ear



Cranial Nerve Primordia



Pharyngeal arches and their nerves:

- Arch 1-trigeminal nerve (V)
  - Maxillary part of arch 1-maxillary nerve (trigeminal, V2)
  - Mandibular part of arch 1-mandibular nerve (trigeminal, V3)
  - Pretrematic branch-ophthalmic nerve (trigeminal, V1)
- Arch 2-facial nerve (VII)
  - Pretrematic branch-chorda tympani
- Arch 3-glossopharyngeal nerve (IX)
  - Pretrematic branch-tympanic nerve
- Arch 4-vagus n. (X)
- Arch 6-vagus n. (X)

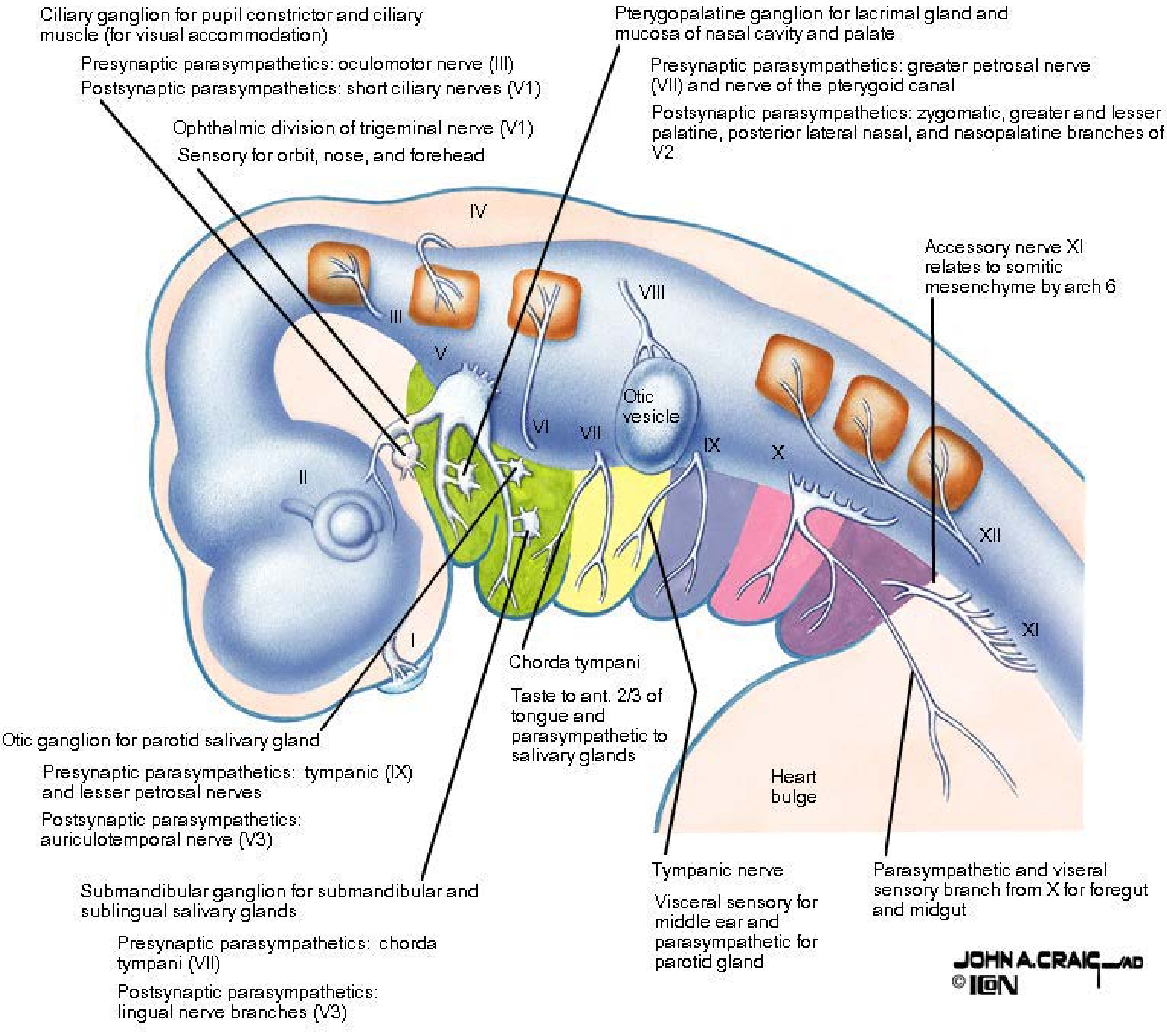
Somite primordia and their nerves:

Preotic somitomeres-oculomotor nerve (III),
trochlear nerve (IV),
abducens nerve (VI)
Postotic somites-hypoglossal nerve (XII)
Somitic mesenchyme-accessory nerve (XI)

Ectodermal structures and their nerves:

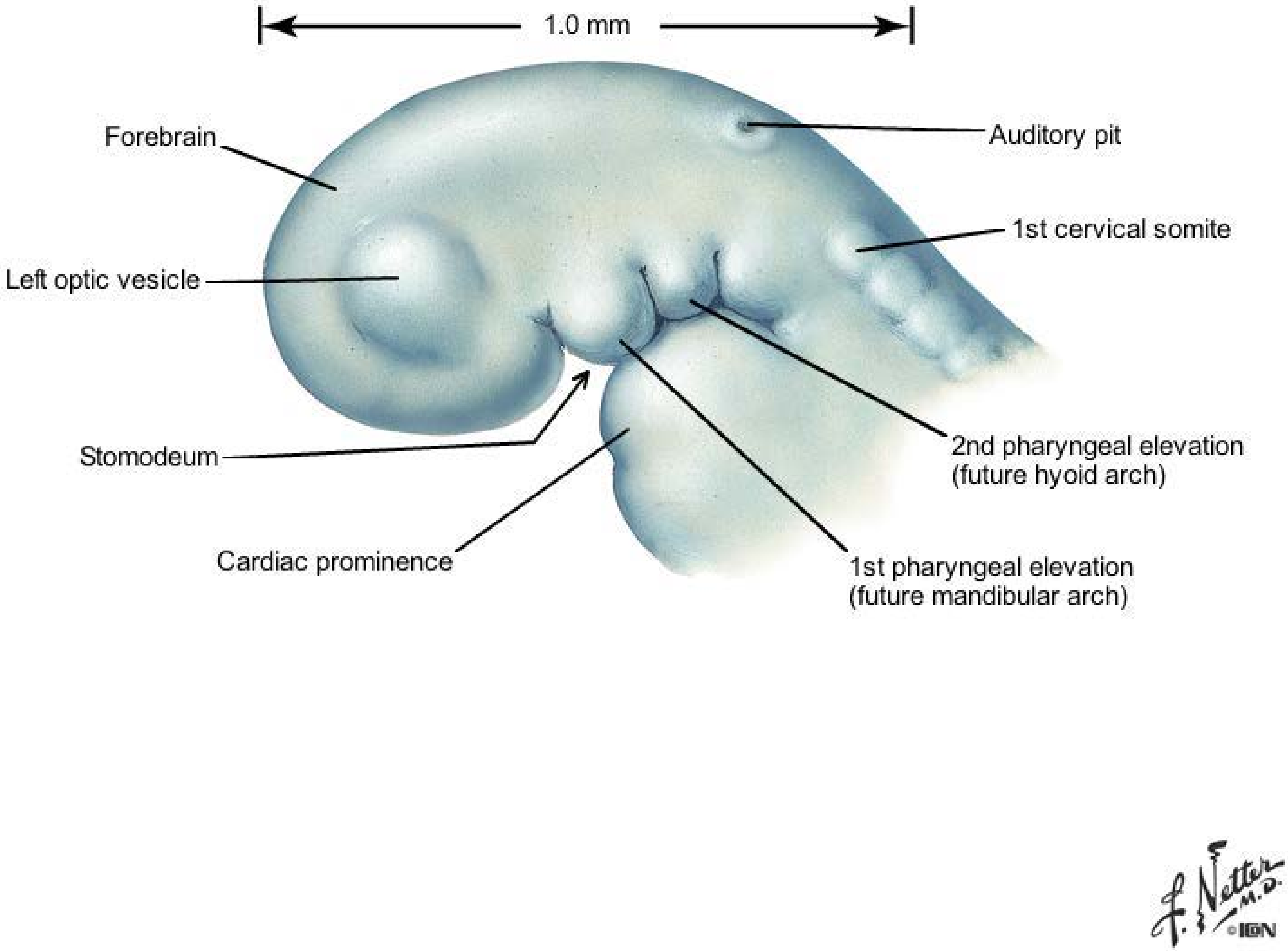
Olfactory placode-olfactory nerve (I)
Optic cup-optic nerve (II)
Otic placode-vestibulocochlear nerve (VIII)

Parasympathetic Innervation and Unique Nerves

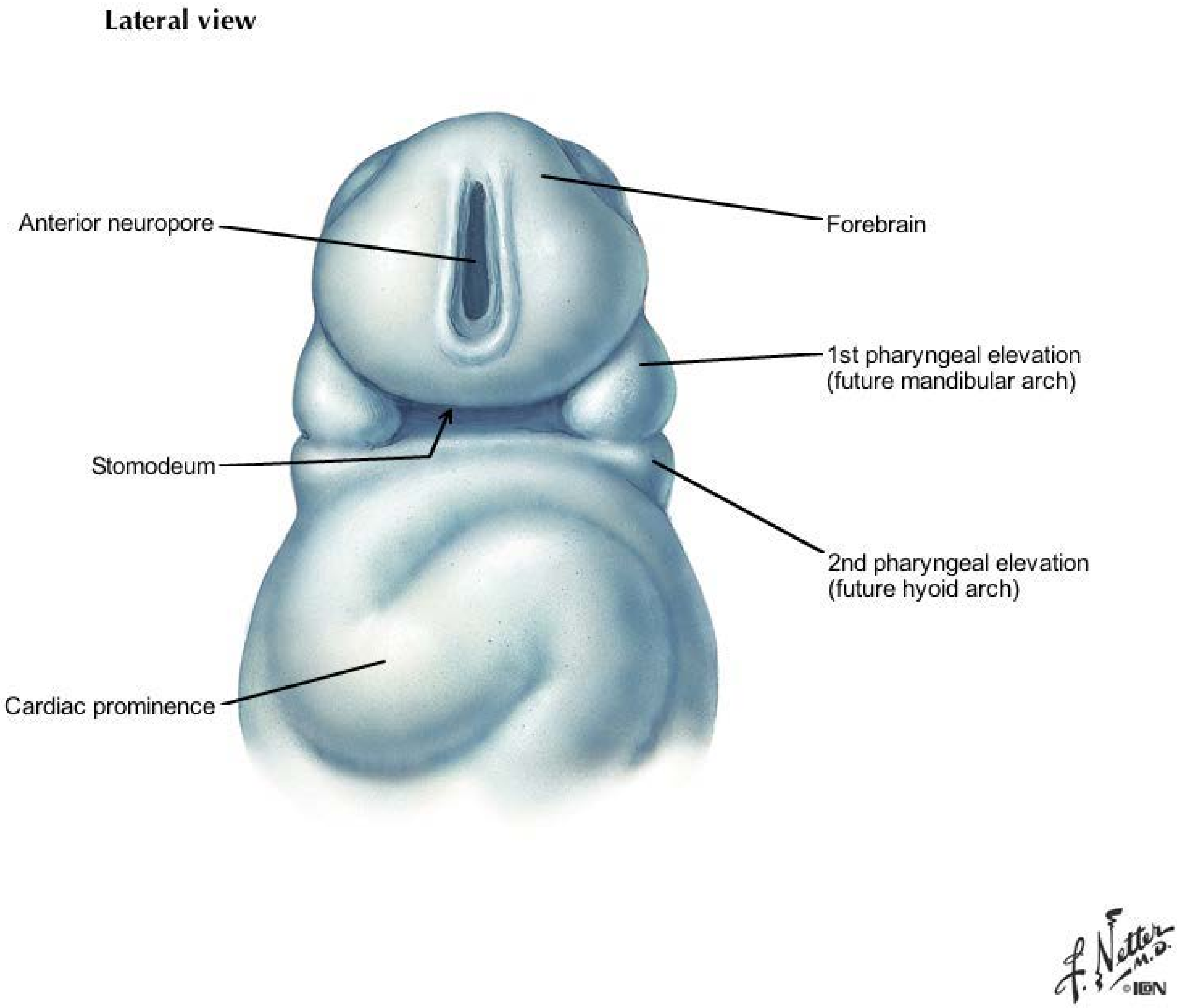


Development of the Face: 3 to 4 Weeks

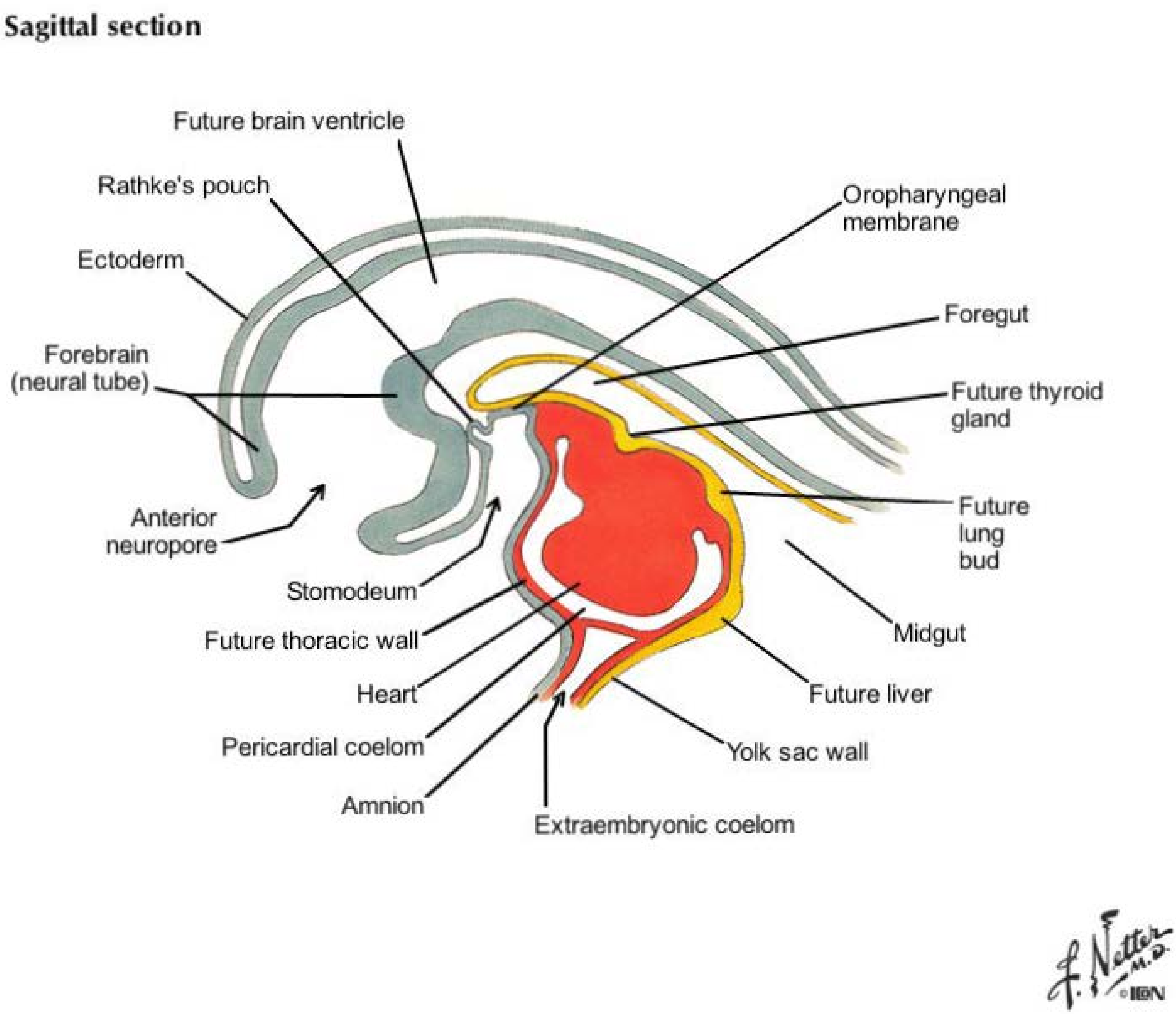
Lateral view



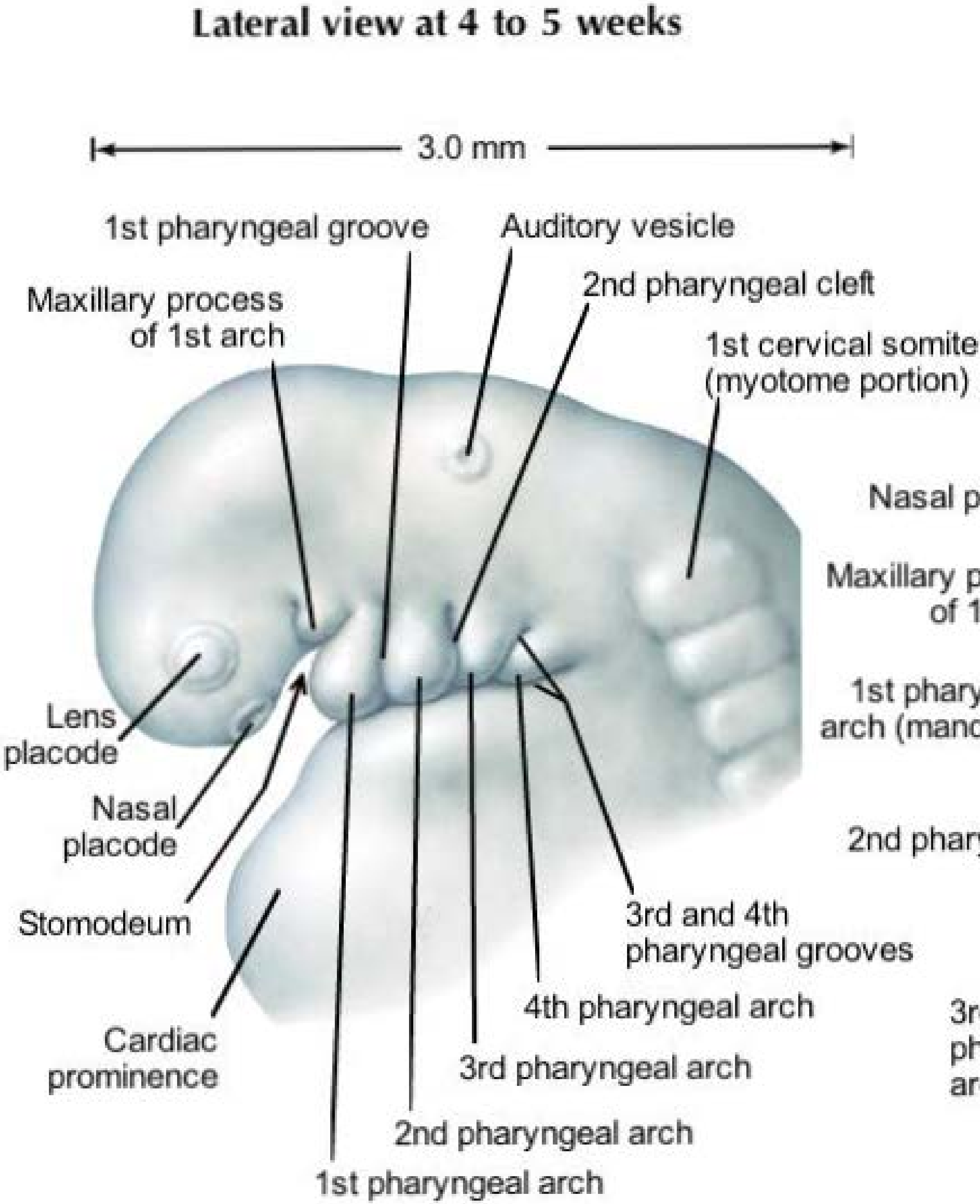
Development of the Face: 3 to 4 Weeks

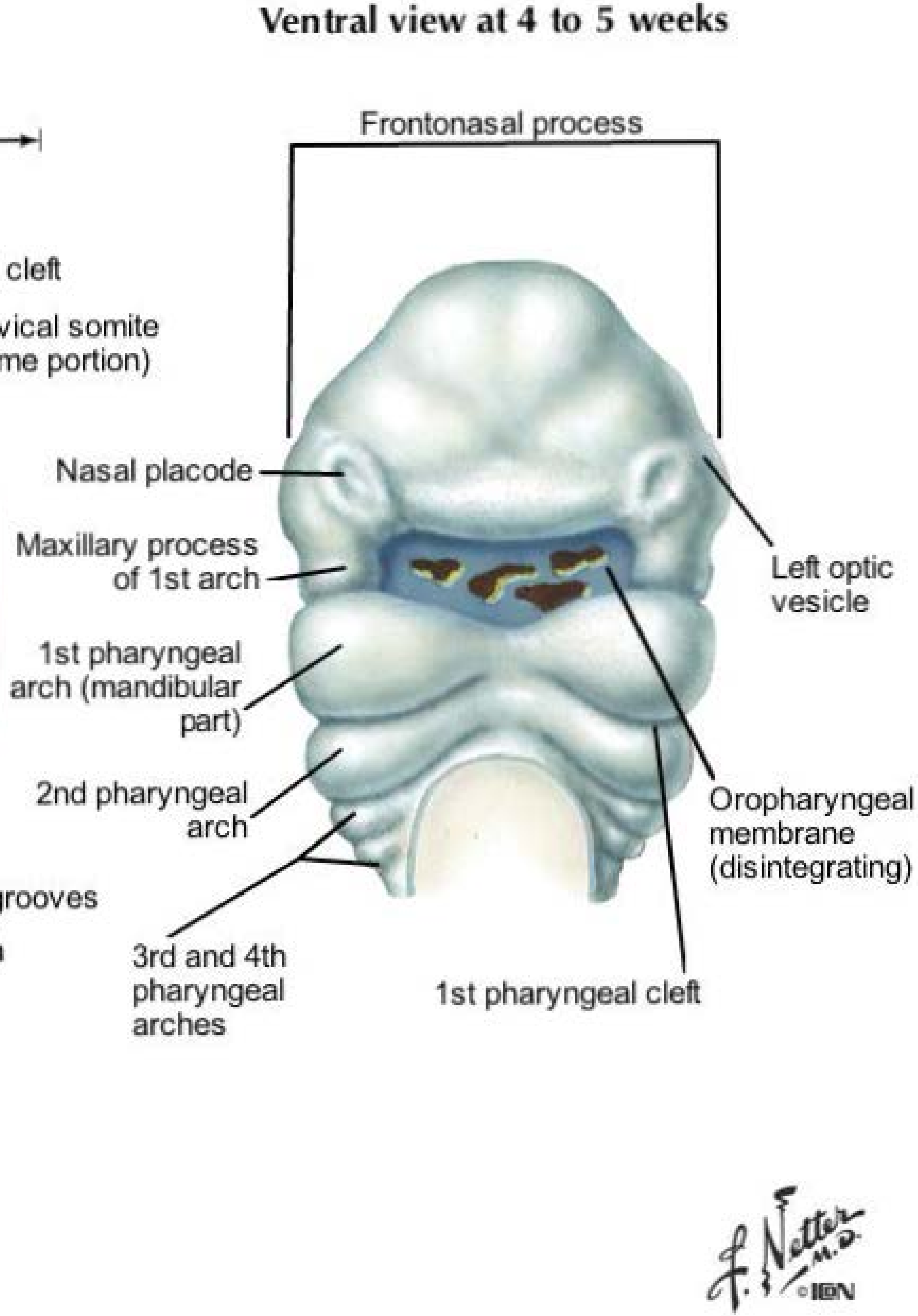


Development of the Face: 3 to 4 Weeks

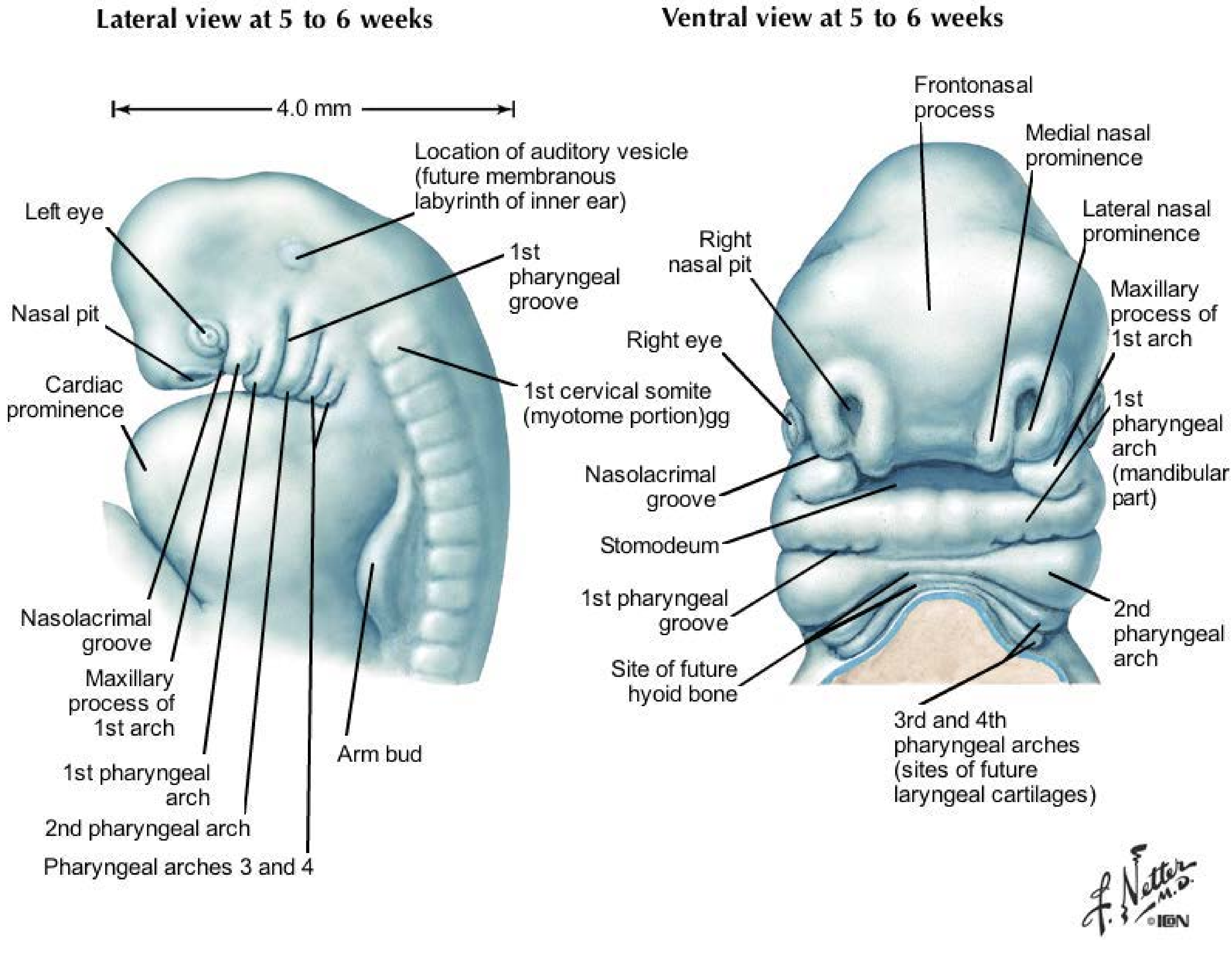


Early Development of the Face: 4 to 6 Weeks



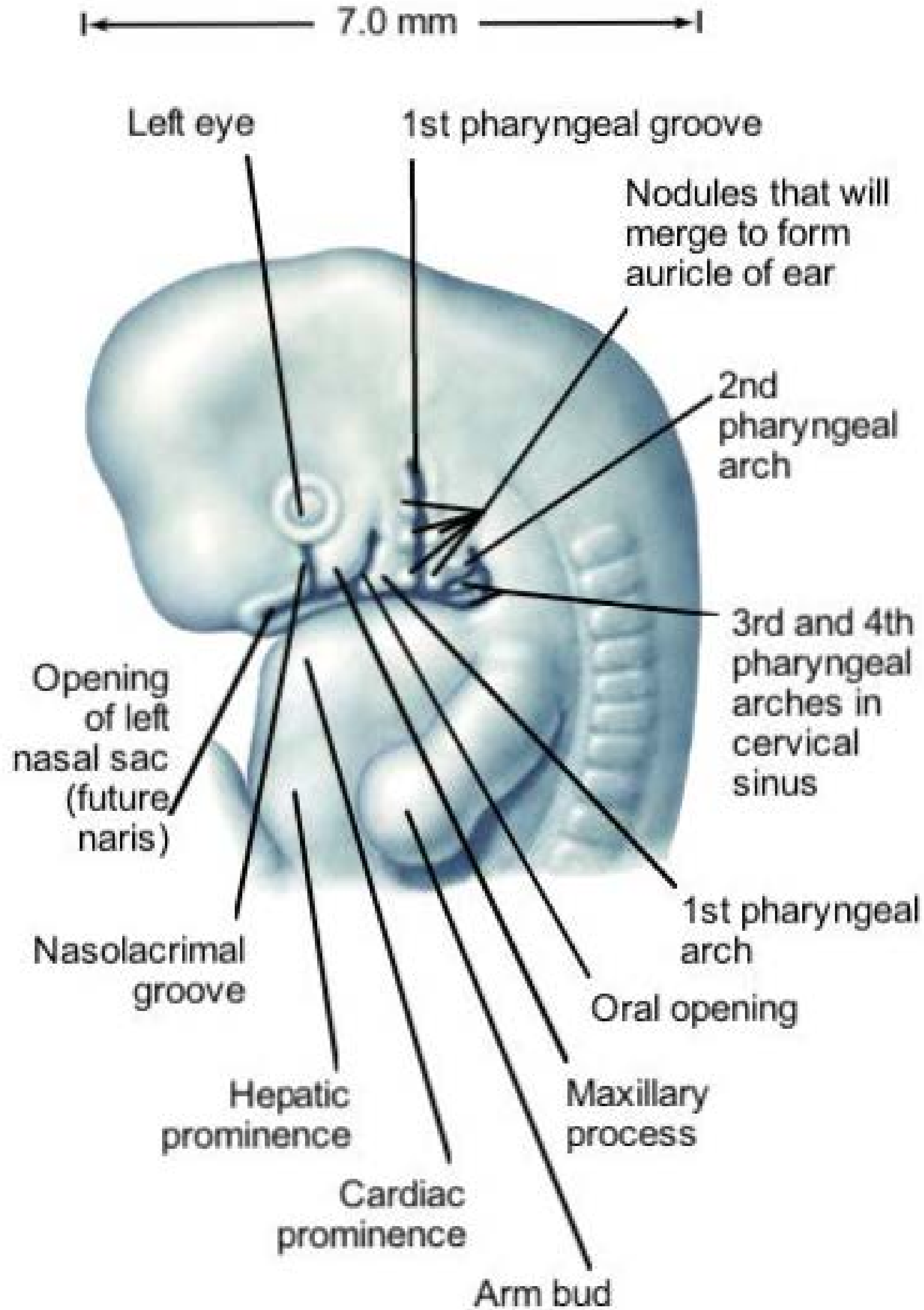


Early Development of the Face: 4 to 6 Weeks

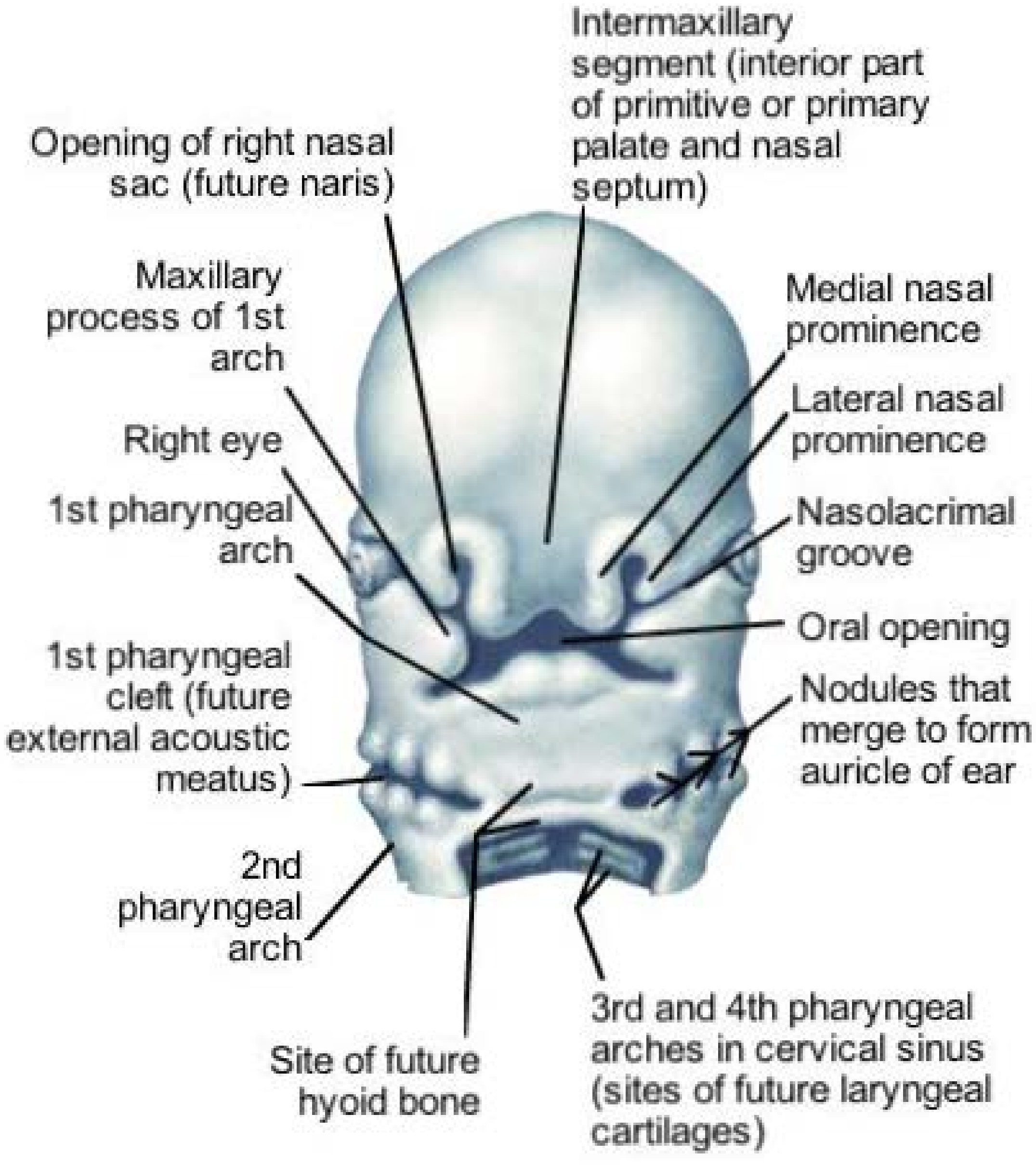


Later Development of the Face

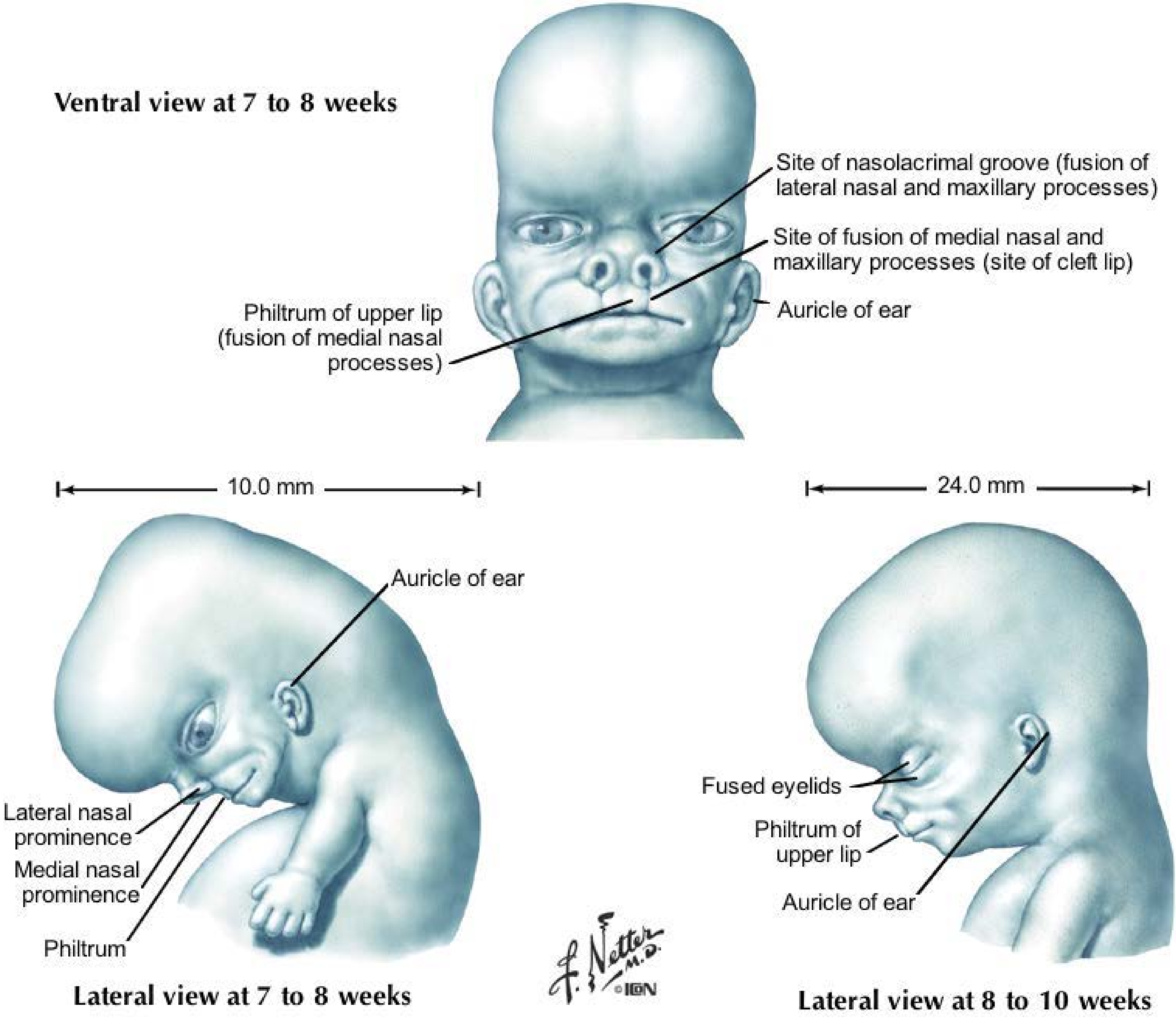
Lateral view at 6 to 7 weeks



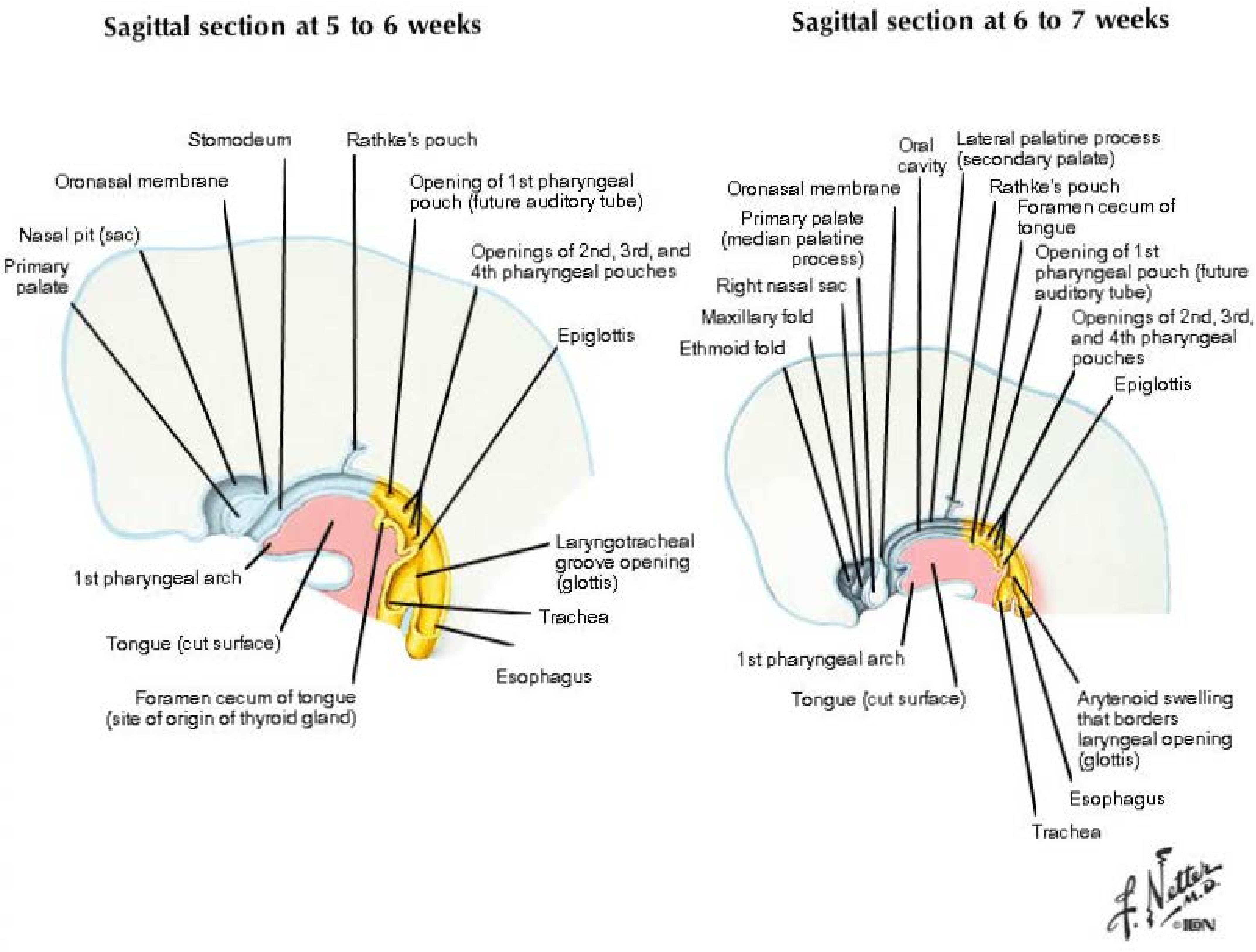
Ventral view at 6 to 7 weeks



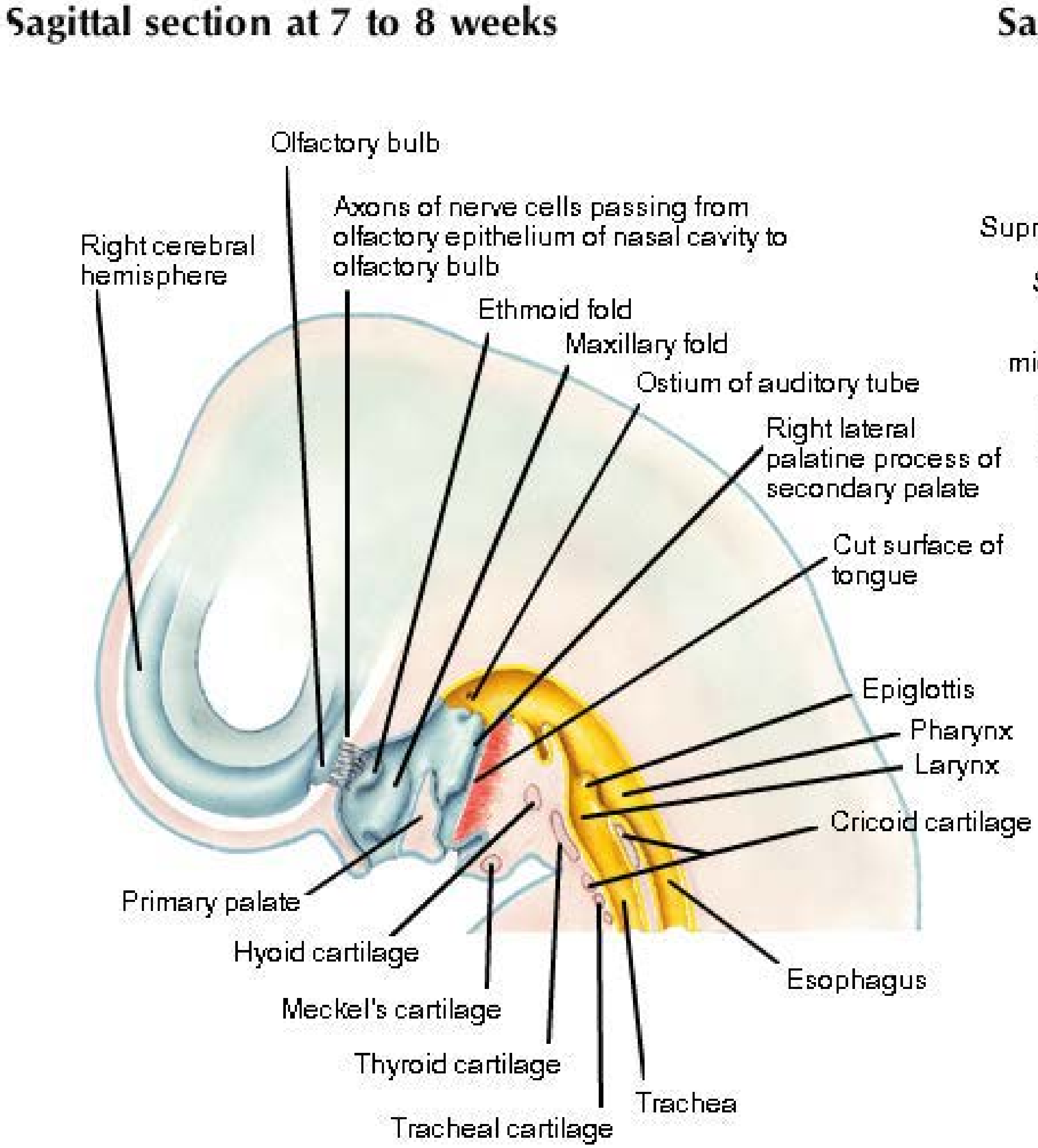
Later Development of the Face

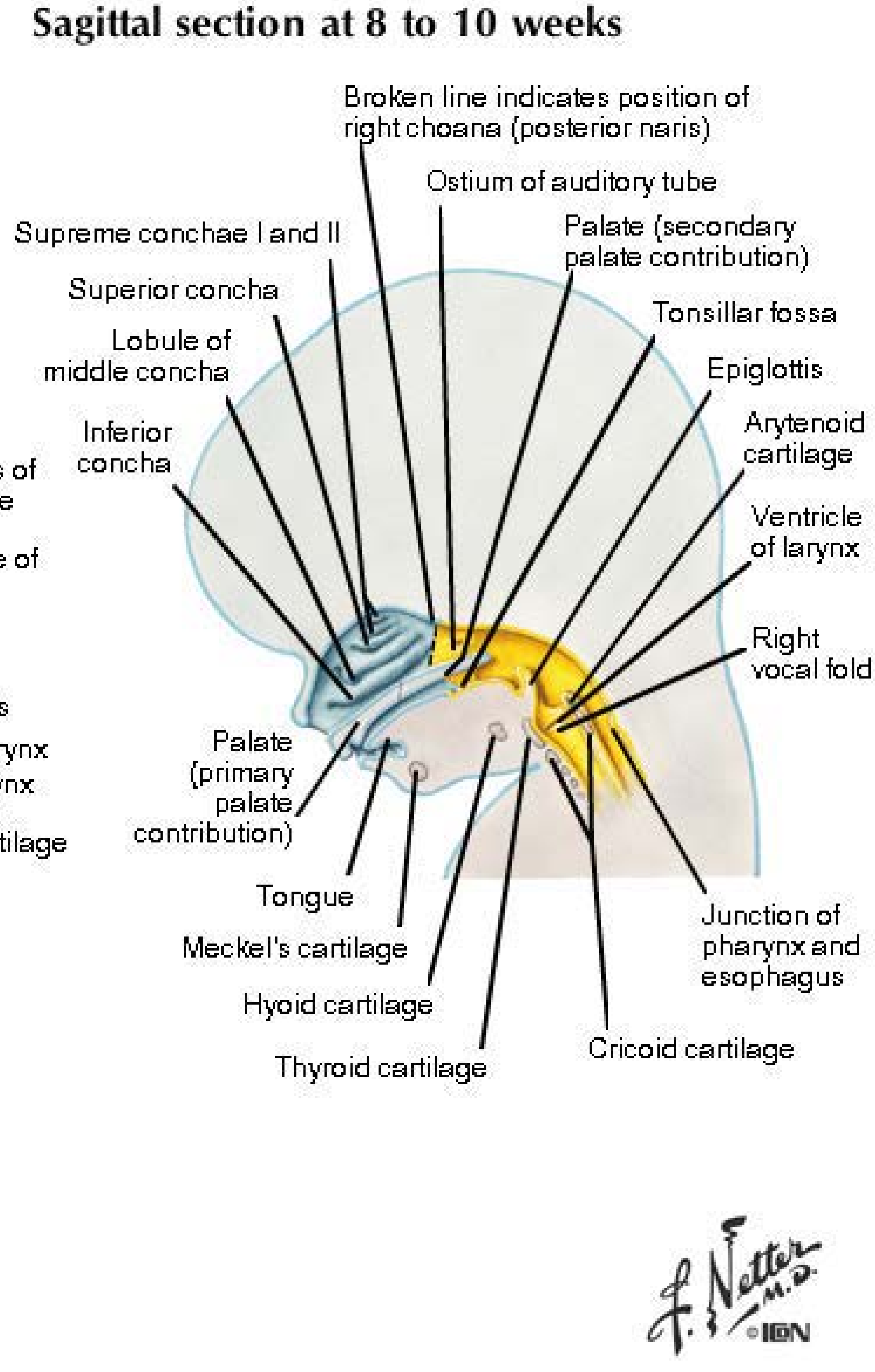


Palate Formation

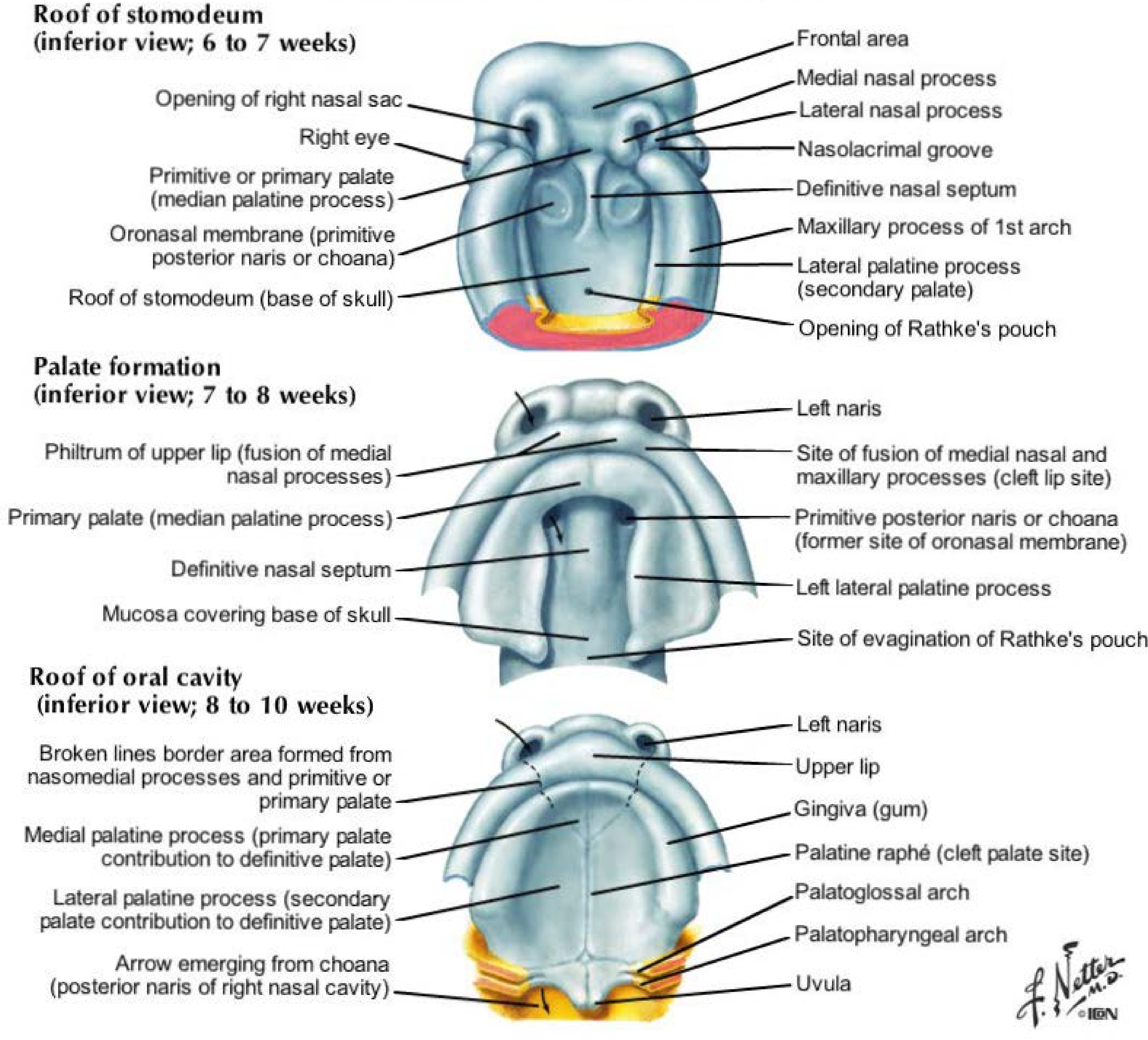


Palate Formation

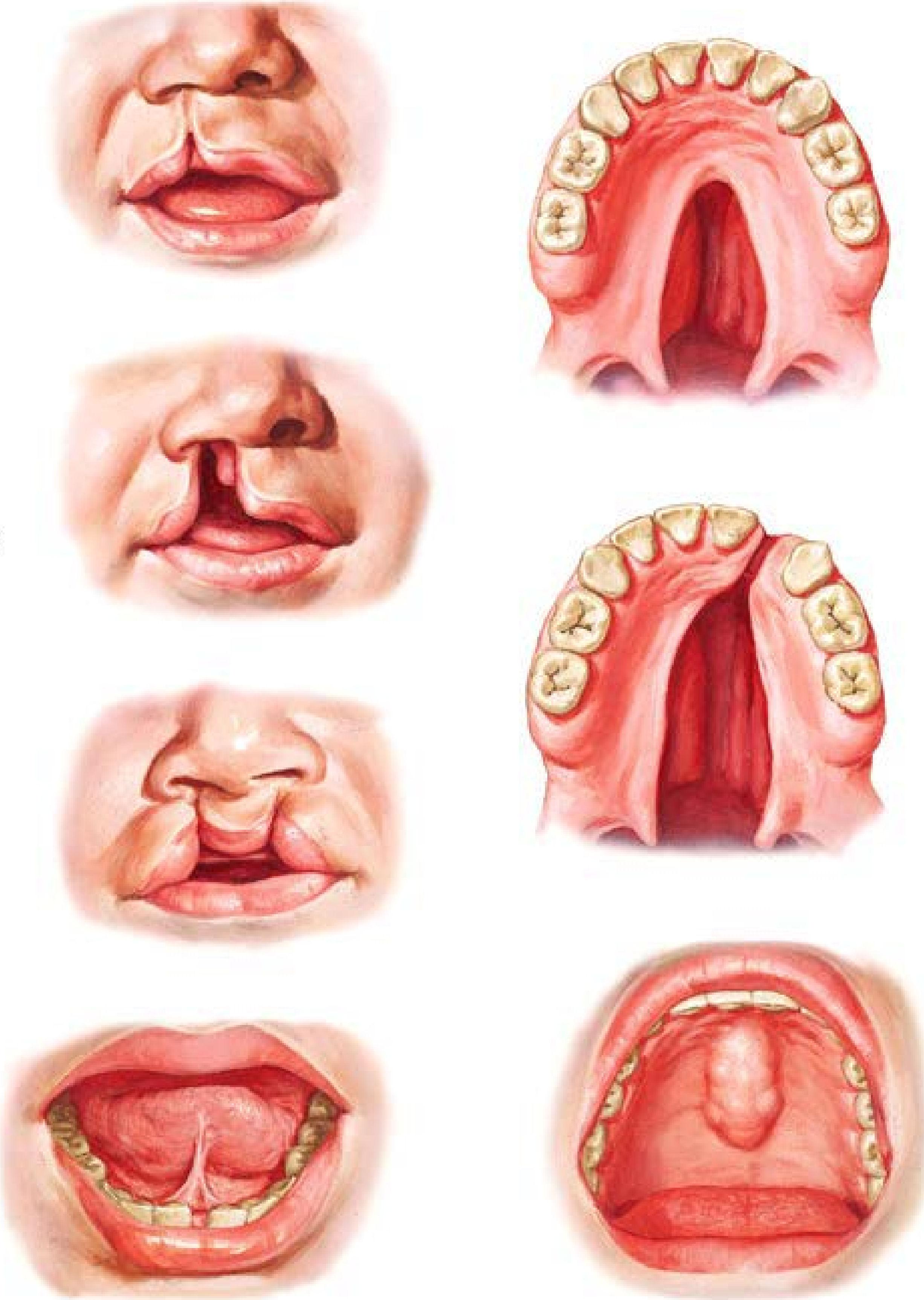




Interior View of Palate Formation



Congenital Anomalies of the Oral Cavity



Unilateral cleft lip-
partial

Partial cleft
of palate

Unilateral cleft of
primary palate-
complete, involving
lip and alveolar ridge

Complete cleft of
secondary palate
and unilateral cleft
of primary palate

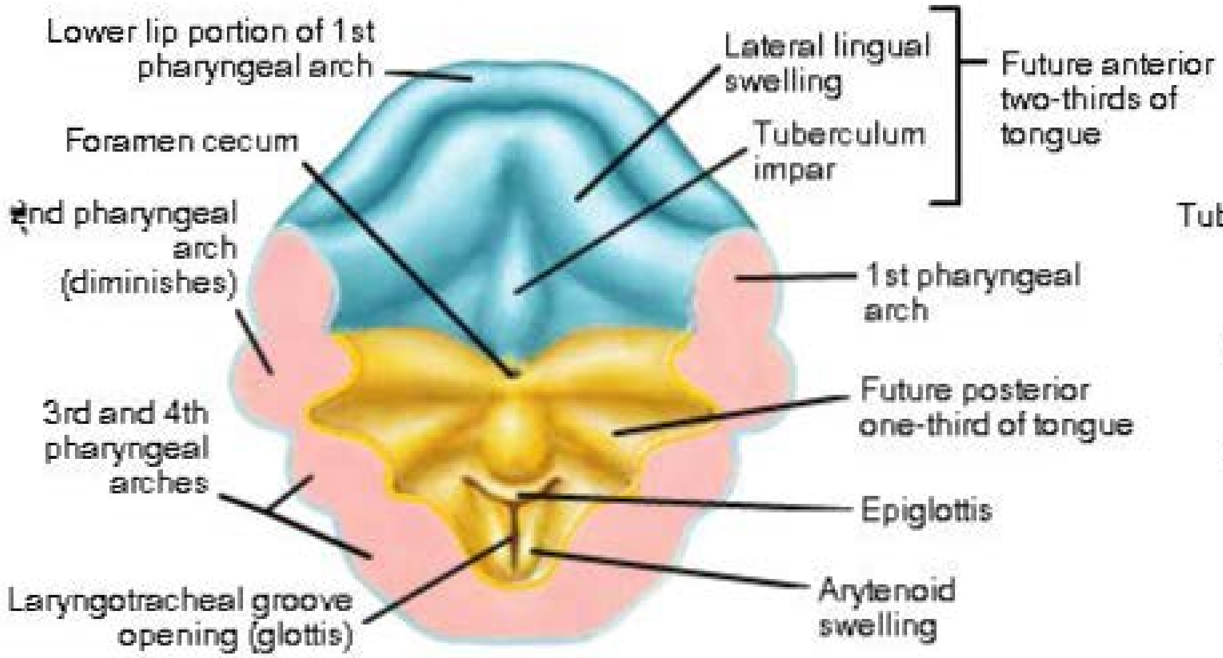
Bilateral cleft lip

Torus palatinus-bone
deposition on palate

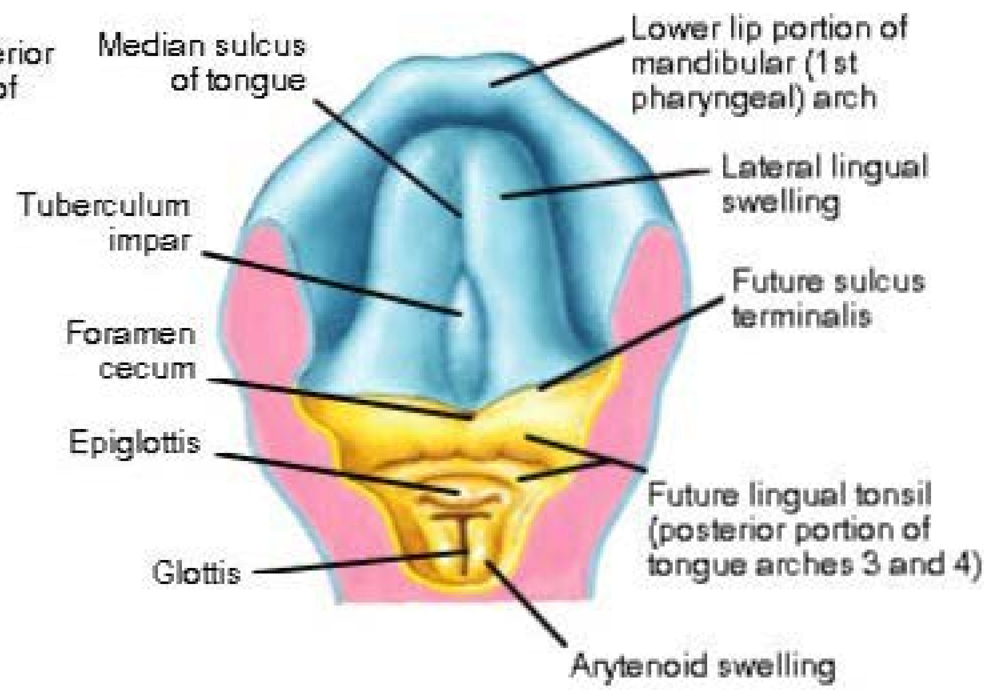
Ankyloglossia-
restricted tongue
movement from a
short lingual
frenulum

Floor of the Oral Cavity

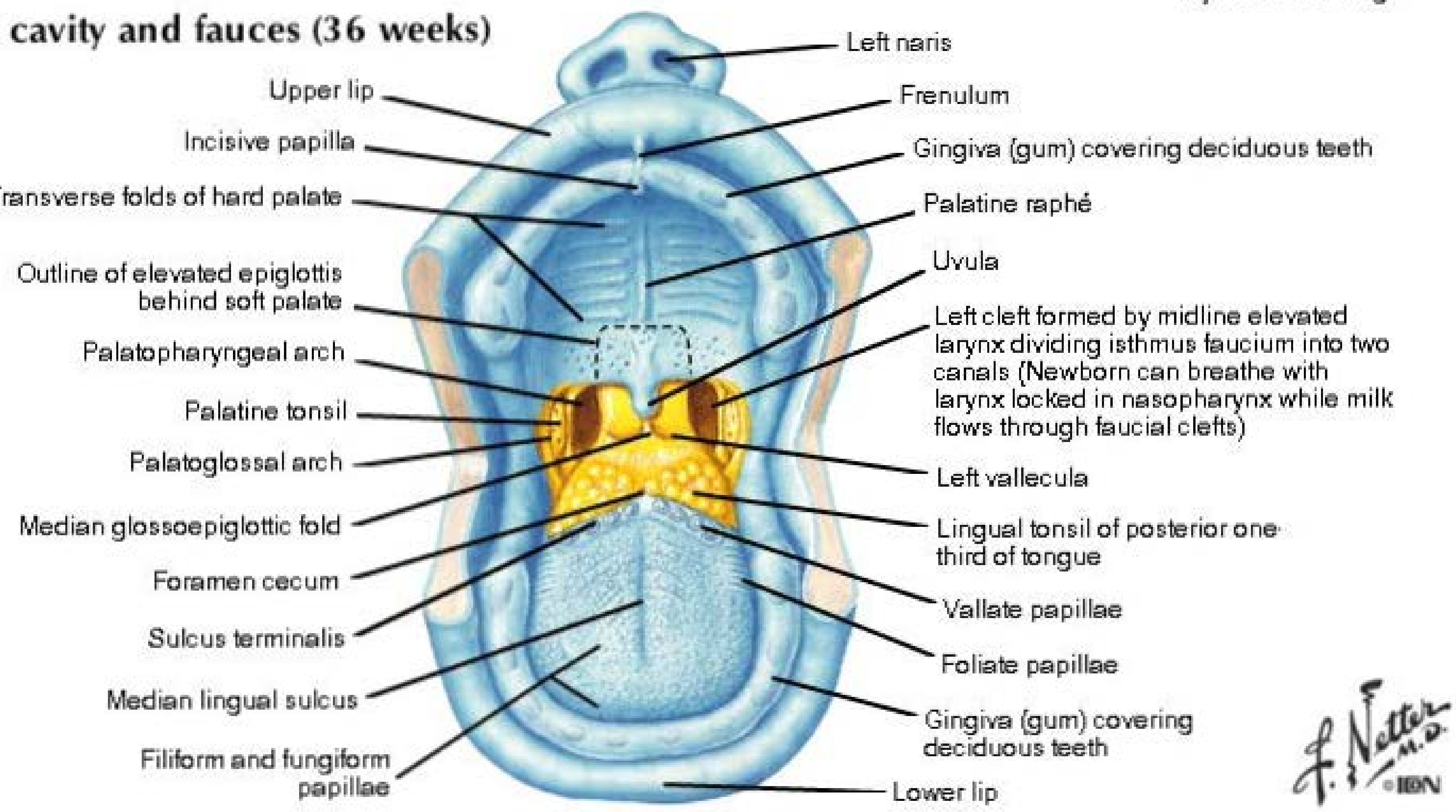
Floor of oral cavity and pharynx (superior view; 5 to 6 weeks)



Floor of oral cavity and pharynx (superior view; 6 to 7 weeks)

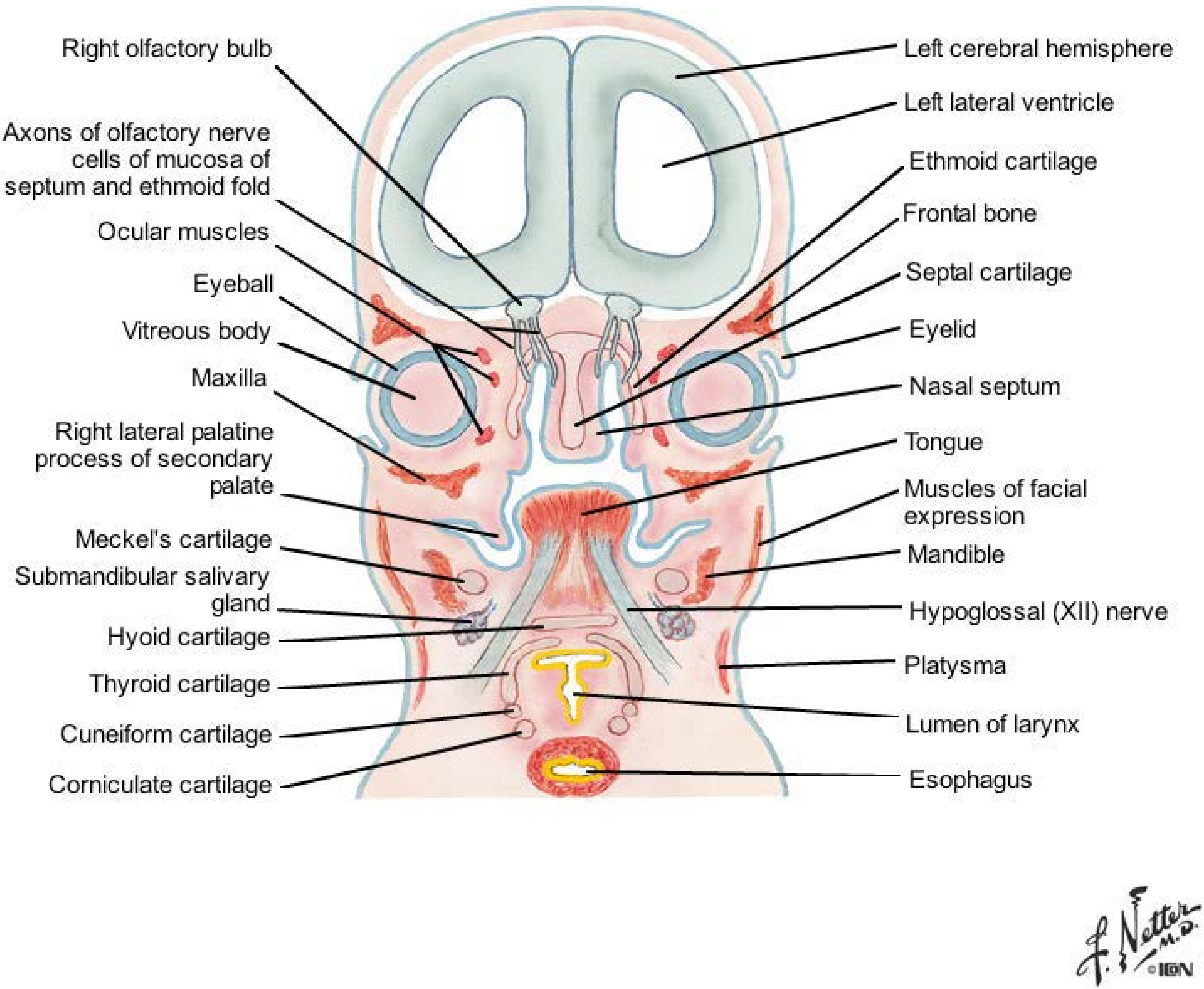


Oral cavity and fauces (36 weeks)



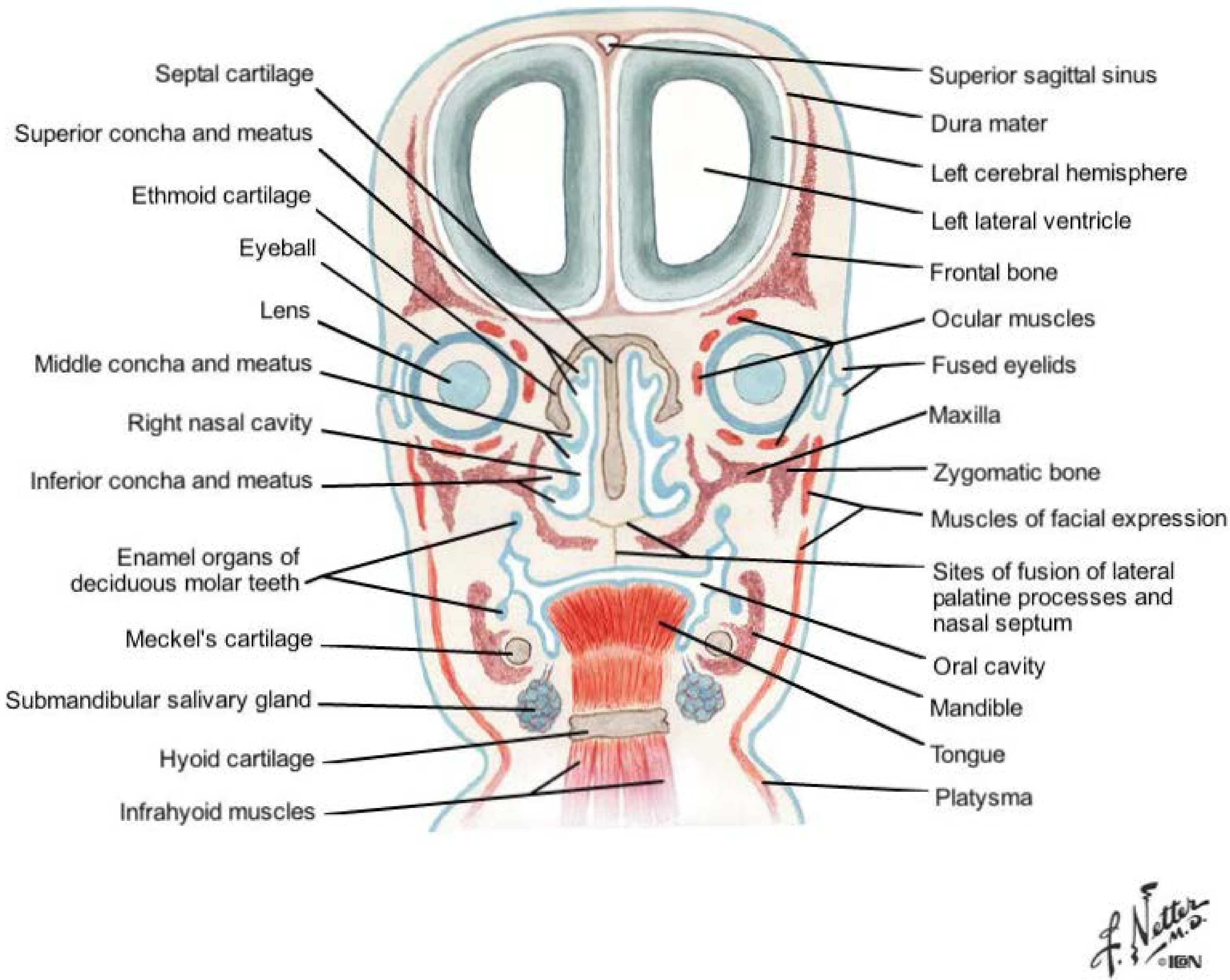
Developmental Cross Sections

Frontal (coronal) section at 7 to 8 weeks

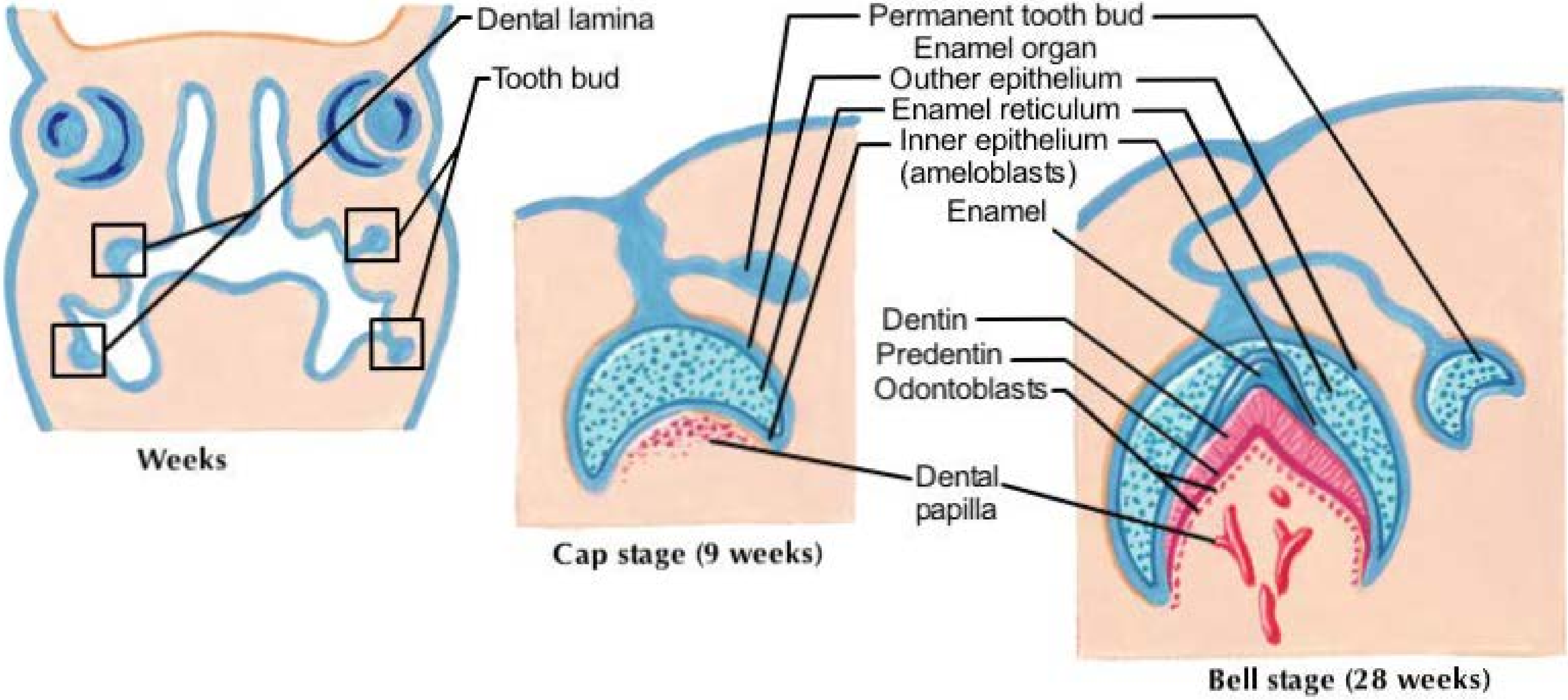


Developmental Cross Sections

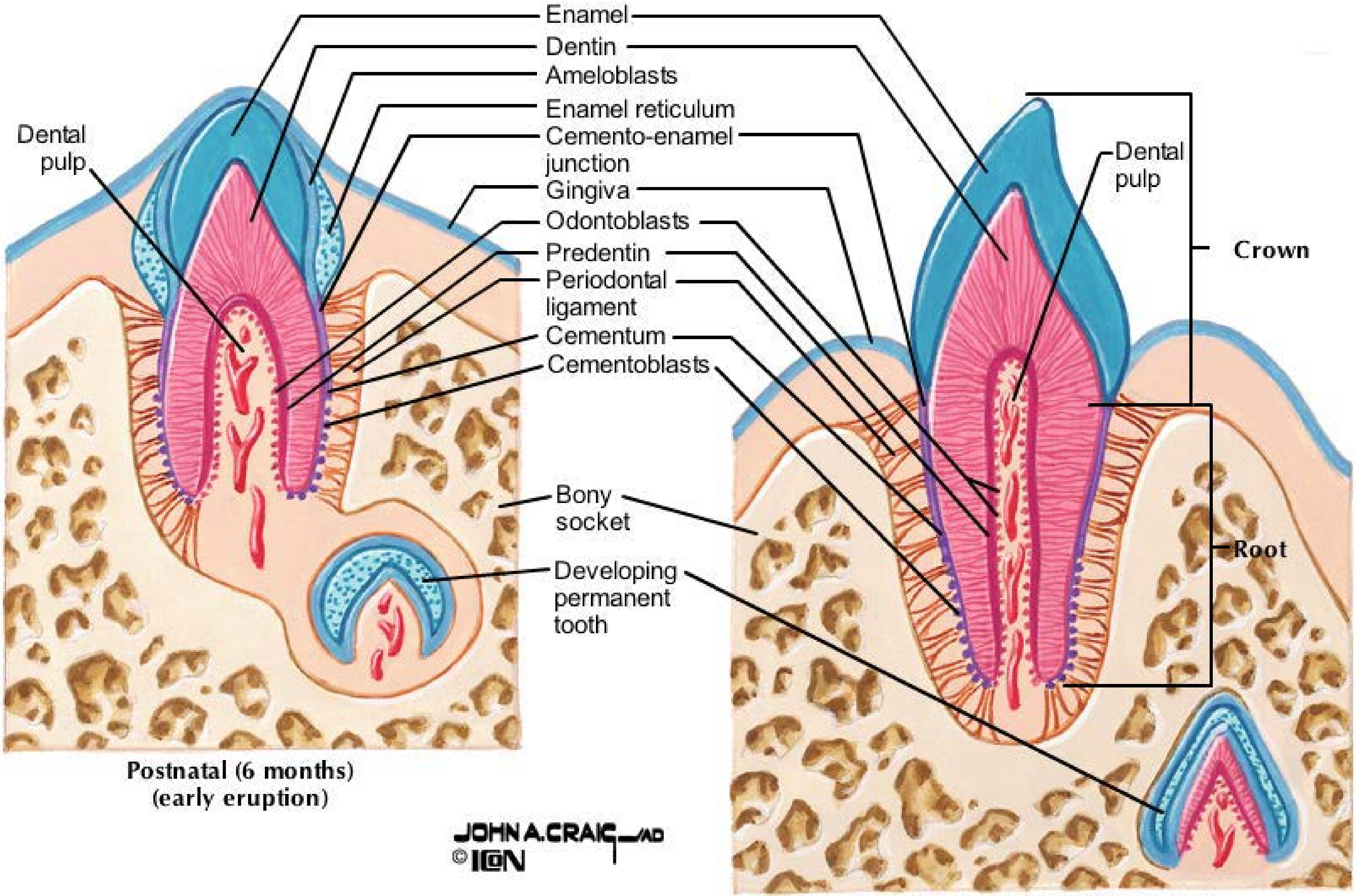
Frontal (coronal) section at 8 to 10 weeks



Tooth Development



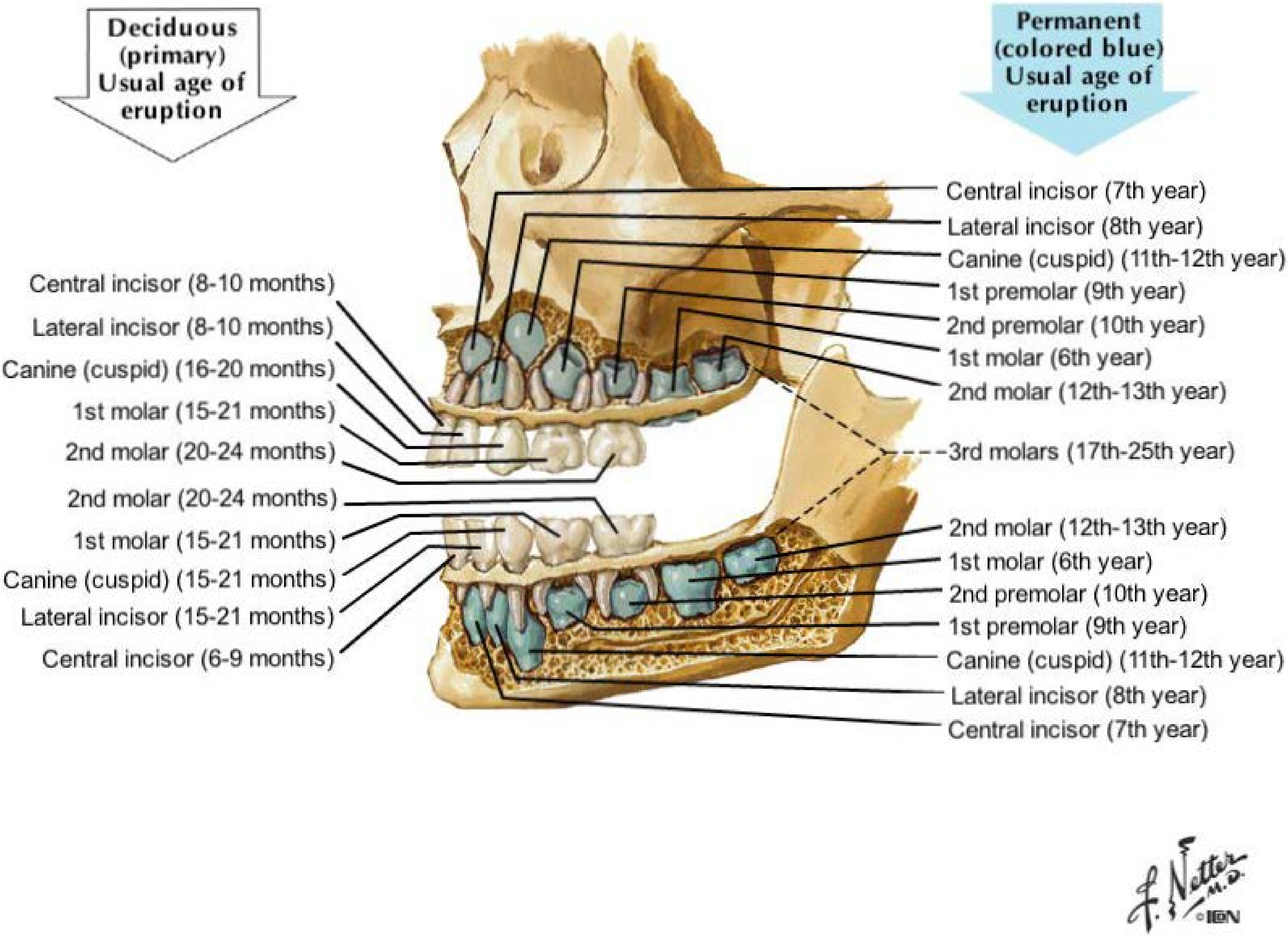
Tooth Development



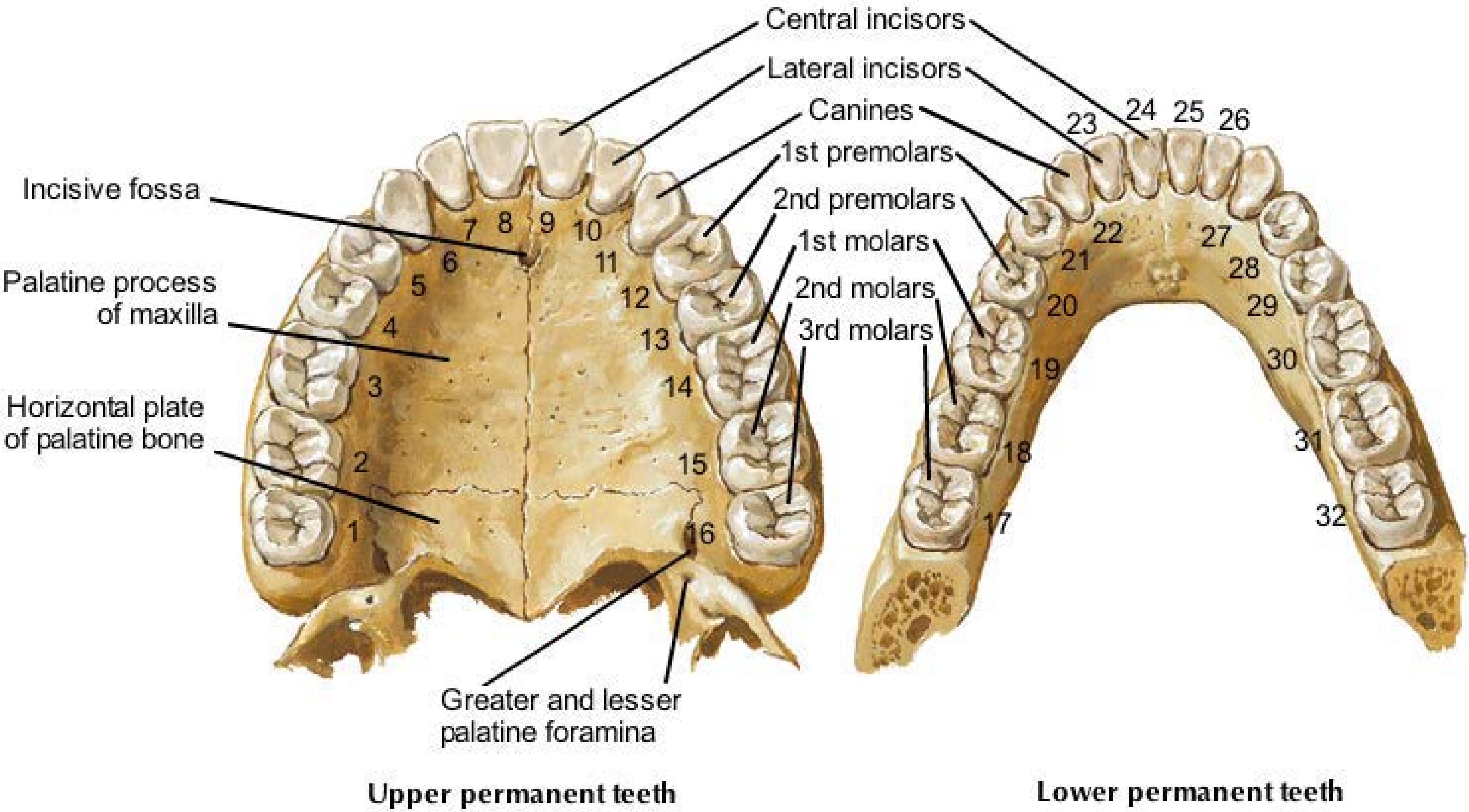
Postnatal (6 months)
(early eruption)

Postnatal (18 months) (eruption)

Dental Eruption



Dental Eruption



Note: Numbers refer to a common scheme dentists use to identify teeth. (Letters are used for the deciduous definition.)

Pharyngeal Pouch and Groove Derivatives

No.	From Pouches	From Grooves
1	Auditory tube, middle ear cavity, mastoid air cells	External auditory meatus
2	Palatine tonsil crypts	Cervical sinus (disappears)
3	Inferior parathyroids, thymus	Cervical sinus (disappears)
4	Superior parathyroids, parafollicular cells (C cells) of thyroid	Cervical sinus (disappears)

Ear Structures and Their Primordia

Structures	Primordia
Auricle	Mesenchyme of the 1st and 2nd pharyngeal arches
External auditory meatus	1st pharyngeal groove (ectoderm)
Middle ear cavity; auditory tube, mastoid air cells	1st pharyngeal pouch (endoderm)
Cochlea and semicircular canals	Otic placode/otocyst (ectoderm)
Tympanic membrane	1st pharyngeal membrane (ectoderm/endoderm) with intervening mesenchyme
Ear ossicles	1st pharyngeal arch cartilage (incus and malleus) 2nd pharyngeal arch cartilage (stapes)
Temporal bone	Occipital sclerotomes (mastoid and petrous parts) 2nd pharyngeal arch cartilage (styloid process) 1st pharyngeal arch mesenchyme (squamous and tympanic parts)

Special sensory and Somatomotor Cranial Nerve Components

Nerve	Primordium Innervated	Neuron Components
Olfactory (I)	Olfactory placode	Special sensory (olfaction)
Optic (II)	Optic cup	Special sensory (vision)
Vestibulocochlear (VIII)	Otic placode	Special sensory (hearing and balance)
Oculomotor (III)	Preotic somitomere	Somatomotor to extraocular eye muscles Parasympathetics to ciliary ganglion (for pupil constrictor and ciliary muscle)
Trochlear (IV)	Preotic somitomere	Somatomotor to superior oblique muscle
Abducens (VI)	Preotic somitomere	Somatomotor to lateral rectus muscle
Hypoglossal (XII)	Postotic somites	Somatomotor to tongue muscles
Accessory (XI)	Somitic mesenchyme by arch 6	Somatomotor to sternocleidomastoid and trapezius

Pharyngeal Arch Cranial Nerve Components

Nerve	Arch	Neuron Components
Trigeminal (V)	1	General sensory (face, orbit, nasal and oral cavities) Branchiomotor (muscles of mastication; tensor tympani; tensor veli palatini)
Facial (VII)	2	Branchiomotor (muscles of facial expression; stylohyoid; posterior digastric; stapedius) Special sensory (taste to anterior two-thirds of tongue) Parasympathetic to pterygopalatine and submandibular ganglia (for lacrimal gland, nasal mucosa, and salivary glands)
Glossopharyngeal (IX)	3	Visceral sensory to pharynx Branchiomotor to stylopharyngeus Parasympathetic to otic ganglion (for the parotid gland) Special sensory (taste to posterior tongue; carotid body and sinus)
Vagus (X)	4 and 6	Branchiomotor (pharynx and larynx) Visceral sensory (larynx; foregut below pharynx and midgut) General sensory to external acoustic meatus Parasympathetics (enteric ganglia of foregut and midgut) Special sensory (taste in laryngopharynx; carotid body and sinus)

Innervation of the Tongue

INNERVATION OF THE TONGUE

Anterior two-thirds (oral cavity)	General sensory (GSA)—lingual branch of V3 Taste (SVA)—facial nerve (VII)
Posterior one-third (oropharynx)	Visceral sensory (GVA)—glossopharyngeal nerve (IX) Taste (SVA)—glossopharyngeal nerve (IX)
Root (laryngopharynx)	Visceral sensory (GVA)—vagus nerve (X) Taste (SVA)—vagus nerve (X)
Tongue muscles	Somatomotor—hypoglossal nerve (XII)

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